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Topics of the Month

The changing chemical industry

THE mid-century is a convenient point in time to review and assess the advances and achievements in science and industry over the past hundred years. At their 113th annual meeting, held last month in Edinburgh, the British Association for the Advancement of Science assembled a number of outstanding scientists and industrialists to discuss the past century from their own particular viewpoints. Mr. H. W. Cremer, a well-known chemical engineer and president of the Royal Institute of Chemistry, contributed what he called some general considerations to the theme 'The Changing Face of the Chemical Industry' in the chemistry section of the meeting.

After a brief preliminary reference to the effects produced by the rapid growth of the chemical industry during the 19th century, Mr. Cremer outlined some of the factors which, in his opinion, had influenced the trends in its development in more recent years. In particular, he stressed some of the undesirable features of the industry in its earlier history, such as atmospheric and water pollution, and he attributed a considerable measure of responsibility for this to a general public which permitted these happenings without active protest.

Among the factors he cited as giving rise to a different outlook and better conditions within and without the industry were the following:

Firstly, the increasing competition from the growing number of industrially-minded countries abroad, necessitating higher process efficiencies and consequently less waste of materials to the atmosphere or to streams and rivers. Secondly, the extension of the industry to include a much wider range of products such as textiles, foods, pharmaceutical preparations, etc., which of their very nature necessitated manufacturing techniques entirely different from those employed hitherto in the so-called 'heavy' chemical industry. Today, agricultural requirements of fertilisers and insecticides also formed a very important part of the chemical industry, and the prospect opened up by the utilisation of synthetic plastics appeared almost limitless. Concurrently with these changes had occurred a blending of the pure and applied sciences in place of a rather marked differentiation between them which characterised the attitude in many teaching circles during the earlier part of the present century. He regarded as of great significance this unification of outlook in the approach to problems in modern chemical industry, where mathematicians, physicists, chemists, biologists, geologists and metallurgists worked, as required, in teams rather than as individuals.

As for the appliances employed in this extremely varied and far-reaching industry, scientific discovery, if it was to be applied usefully, made more and more exacting demands upon the designer and fabricator of chemical equipment. Many present-day processes, operated upon an immense scale, required pressures undreamed of on an industrial scale even a few decades ago, and sometimes these high pressures had to be combined with comparatively high temperatures. Not only had the chemical engineer made many contributions in this field in extending knowledge of the principles on which plant design was based, but his work would be largely unavailing had not the metallurgist produced the special constructional materials needed to implement these designs. One outstanding contribution which the chemical engineer had made was to view in selected categories, instead of piecemeal, the process operations used in the very extensive range of industries with which he was concerned. He had recognised that the physical principles underlying these operations were the same, however, different in form the appropriate appliance might be for a particular product. This apparently obvious concept had quite revolutionised the teaching and profession of chemical engineering, and chemical industry had greatly benefited accordingly. Today the chemical engineer recognised a number of 'unit operations,' such as size reduction, size separation, evaporation, drying, distillation, filtration and so on. The principles underlying them were common to *all* industries, although the actual method of applying these principles might differ with the properties of the individual product to be manufactured. Mankind could not reap the benefit of the genius of the research chemist unless the chemical engineer was able to translate the work of the laboratory to the factory scale, and in this respect immense strides had been and were still being made.

Lastly, Mr. Cremer referred to the safety and welfare of the workers employed in this vast industry, and to some of the hazards which they encountered. The study of occupational diseases had advanced greatly in recent years, and this factor, together with the others to which he had referred, had clearly created in his mind the picture of an industry, somewhat haphazard and irresponsible at its outset, but which was now integrated and much more conscious of its obligations to the public which it directly or indirectly affected. He believed the time had arrived when there was a much better prospect of science being properly wedded to industry and in turn industry to civilisation.

France short of soda products

THE shortage of coal in France has led to a marked tightening in the supply of soda-base products, since their manufacture requires relatively large quantities of fuel. The tightness is particularly marked in sodium bichromate and caustic soda and is thus felt especially by the textile industry, one of the largest users of these products.

Only one firm in France, Société Kuhlmann, produces sodium bichromate, and it has to supply seven industries, chief of which is the textile industry. Kuhlmann at present produces about 500 tons/month, which is only about 62% of monthly requirements. Thus 300 tons would have to be imported to bridge the gap but, at the time of writing, no allocation of foreign exchange has been made for this purpose, nor have any quotas been fixed under trade agreements.

Another complication stems from the fact that the world market price of sodium bichromate is about three times the French quotations. The use of imported material would thus raise still further the prices of French textiles. Nevertheless, it is not intended to set up new production facilities in France, since it is held that they could not operate profitably once conditions return to normal.

Exports of soda bichromate from France, provided for under trade agreements, stopped in May and import duties were suspended at the same time.

The shortage of caustic soda is equally grave and affects, in particular, cotton dyeing and finishing plants. While France's own output of about 300,000 tons p.a. would be sufficient to meet all domestic needs, the actual supply available is lower, since 90,000 tons were exported in 1950 and 40,000 tons so far this year. The Government refuses to reduce exports on the grounds that certain obligations were undertaken in international agreements.

In order to limit consumption of caustic soda, deliveries to domestic consumers have been cut to 85% of average consumption during the last three years. This works very much to the disadvantage of the textile industry (which in 1950 accounted for 42% of total French consumption), since the industry did not until this year regain a normal rate of operation. Consequently, several factories in eastern France which engage in the bleaching, dyeing and mercerising of cotton are threatened by closure, even though their annual requirements do not exceed 22,000 tons. Artificial fibre producers, who are the largest consumers, are most seriously affected by the reduction in supplies.

Norway's mineral development plans

THE development programme of the new Norwegian State mining company, A/S Statens Bergverk, the formation of which was noted in these columns in May (p. 209), has been outlined by Hr. Arne Drogseth, the managing director of the company. Regarding pyrites, he states that technical developments have made it possible to exploit relatively poor deposits such as those at Vaddas in Troms Province in north Norway. Experts have been sent to examine the Vaddas deposits and, if their findings are positive, work will be started there. To solve the technical problem of refining the pyrites at the rich Grong mines, co-operation will be started between the technical college at Trondheim and the raw materials laboratory. The Gron pyrites contain iron, copper, lead, zinc, cadmium, as well as sulphur, and a satisfactory refining method must be discovered. Hr. Drogseth added that Britain would rather have pure sulphur than pyrites.

An agreement has been reached with the United States with regard to the sale of niobium concentrate from deposits in Telemark Province. Niobium is an important element in alloys which need to withstand very high temperatures. The niobium concentrate from Telemark contains 60% pure niobium. Production, it is hoped, will start next year. The large chemical concern, Norsk Hydro, is acting as Statens Bergverk's agents in developing the mines.

Another metal for which there is a heavy demand is wolfram, used in the manufacture of hard metals. Western Europe's requirements were formerly met by China, but there are wolfram deposits at Orsdalen in south Norway which are to be examined.

Finally, diamond drillings are being carried out at the site of the Dunderland iron ore deposits in north Norway. The deposits are very large, and work is now proceeding to try to find a satisfactory method of refining the ore.

Chemical engineering training in Brazil

THE University of Sao Paulo, founded in 1934, is one of the main scientific and technical educational centres in Brazil and, as in other countries, was formed from several existing colleges. Degree courses are available in chemical, civil, electro-mechanical, and mining and metallurgical engineering.

The four courses in chemical, civil, electro-mechanical and mining and metallurgical engineering are held at the Escuela Politecnica, founded in 1893 and now part of the university. Entrance to any of the engineering courses is by an oral and written examination in mathematics, chemistry, physics and machine drawing. The courses extend over five years, with the exception of the mining and metallurgical engineering course, which takes six years. After graduation a doctorate can be obtained on one year's work for a thesis on an original subject.

During the first year of the chemical engineering course, some of the subjects studied are the same as for the civil and electro-mechanical engineering courses and include differential and integral calculus, vectors, analytical geometry, physics, mechanical drawing and inorganic chemistry. The subjects are the same in the second year, except for mechanical drawing, which is replaced by analytical chemistry. The third year subjects include analytical and organic chemistry, chemical technology, crystallography, mineralogy and strength of materials. Inorganic, organic, physical and electro-chemistry, chemical technology, applied mechanics and machine drawing are the major subjects studied during the fourth year. The fifth and final year includes thermodynamics, with the fourth year civil and electro-mechanical engineering, inorganic and organic chemistry, biochemistry, chemical technology, metallurgy, metallography, political economy and accountancy.

The degree course in pure chemistry in the Faculty of Science extends over four years and a course in educational psychology is available for those who intend to take up teaching.

High pressures and 'hot ice'

'HOT ice,' which exists at temperatures higher than the boiling point of water, was one of the exotic by-products of recent high-pressure research described by Dr. C. O. Strother of the Linde Air Products Co. at an American Chemical Society dinner at which he received the 1951 Jacob F. Schoellkopf medal. Commercial high-pressure chemical processes are now operated up to 50,000 lb./sq.in. pressure, as contrasted with the pre-war limit of 15,000 lb. However, the high-pressure research described by Dr. Strother was conducted at pressures up to 150,000 lb., and the 'hot ice,' which was produced under the direction of Prof. P. W. Bridgman of Harvard University, was made at a pressure of 600,000 lb./sq.in. Pressures developed in the firing of guns and cannons range from 50,000 to 100,000 lb. sq.in., and the pressure in the deepest part of the ocean —about six miles down—is some 15,000 lb.

High pressures are important in chemical processes because, by bringing the molecules of substances closer together, they bring into play forces of attraction between the molecules that do not operate at the greater distances normally prevailing. For this reason, polythene can be produced from ethylene only by the use of high pressures. High pressures also activate molecules by distorting them, explained Dr. Strother, adding, 'There is no question that the crowding together of the molecules causes associations that do not exist at lower pressures.'

High-pressure research—which the speaker called a 'rather neglected field'—is best carried out in a flow system in which the chemicals are passed through the reaction zone. This creates many peculiar problems. If water is present in the system, ethylene gas will form a solid compound with the water at about 3,000 lb. pressure. This compound will plug up the lines. At 100,000 lb., nitrogen gas will dissolve lubricating oil, a fact which is sometimes troublesome. Most materials are either solids or very thick liquids at these tremendous pressures.

Strother and his colleagues have developed a pump that will behave well somewhat about 100,000 lb./sq.in., but because of the factors just mentioned there are very few materials outside of the permanent gases that remain sufficiently fluid to be pumped at such pressures.

Because of the influence of high pressure on chemical reactions and the profound effects it has on the form in which matter exists, high-pressure work is important in scientific research aimed at understanding the structure of water and the nature of chemical processes. For a high-pressure process to be attractive for large-scale operations, it must be an exceedingly rapid reaction to allow a high throughput. This is because very large-sized thick-walled equipment is not feasible, and even moderate-sized high-pressure equipment is expensive. It is therefore necessary to process a large amount of material through the moderate-sized equipment to justify the investment.

Freight handling

THE handling of freight during transport is akin to the handling of materials in factories in that it increases the cost of goods without increasing their value. Mechanical equipment is being used to a varying but increasing extent in British railway, road and dock premises, but transport providers and users thought that there might be something to learn about such matters in America and it was natural, therefore, that the specialist team on materials handling, whose report was issued last year, should be followed by one on freight handling. Like its predecessor, this team, whose report was published recently, made its visit under the auspices of the Anglo-American Council on Productivity, with Marshall Aid.

In methods of freight handling no startling difference in the standard of achievement in the two countries was apparent, but the visit to the U.S. revealed important variations in technique, in the attitude of mind to mechanisation and in the degree to which particular methods, common to both countries, have found favour in one more than the other. Employees in the U.S. have a fundamental objection to unnecessary physical effort.

Factors that encourage the use of mechanical equipment in the U.S. are the larger average consignments and the greater potential saving in labour costs due to the high wage rates.

Apart from particular refinements and gadgets and the use of the drag-line—a continuous chain, either overhead or under the floor, to which are attached, as required, four-wheeled trolleys—no types of mechanical equipment were seen which are not in general use in Britain, but there was much wider application and more intensified use. The team was particularly interested in the use of pallets in transport. In factory, depot and dock operation palletisation on permanent pallets was found to be highly developed—'Keep

the goods off the floor' was the dominant aim. As a result there is a keen search in the U.S. for ideal types of expendable (one-trip) pallets which need not be returned, but the team points out that as this device would entail a not inconsiderable consumption of relatively expensive materials its general adoption by British traders in present circumstances is unlikely. Standardisation of pallet sizes has progressed no further in the U.S. than here, nor did the team find in the U.S. any pallet pools, with general common user and interchangeability.

Based on these general conclusions are the following, among other, recommendations:

Particular emphasis is laid on the potentialities in general transport use afforded by (i) Fork-truck operation, either with pallets or, for suitable traffics, pusher or specialised attachments on the fork trucks; (ii) The development of palletisation and the unit load for throughout transport; and (iii) The drag-line method of mechanising transport depots.

There should be the widest possible dissemination and exchange of information and experience on freight-handling methods.

The management-labour co-operation on the maximum use of mechanical equipment which prevails in America should be followed energetically in all phases of freight handling in Britain.

Development of Transvaal phosphate deposits

THE South African Government plans to establish a Utility Development Corporation to exploit the large phosphate deposits in north-eastern Transvaal and thus provide a steady flow of fertiliser material to Union agriculture. All rights in the exploitation and development of the deposits will be taken over by the Government, according to an announcement by the Minister for Economic Affairs Mr. Louw.

A steady supply of phosphate to superphosphate factories is regarded as so important that the project has been designated a key industry. The final form in which the industry is to be operated will be determined by the Cabinet.

Hitherto, about 90% of South Africa's requirements of phosphate have had to be imported in the form of rock phosphate. The new industry will be designed to make the country ultimately independent of imports. It is expected that the quality of the Transvaal material will prove equal to or better than that of imports.

Explaining the Government's decision to control phosphate production itself, Mr. Louw said it was still his policy to encourage private enterprise, but in this case the Government was dealing with a key industry of vital importance to the Union which should be considered in the same way as, for example, the oil-from-coal industry.

By-products of the latter industry will be a valuable adjunct to the phosphate scheme, and this might mean that the Union will be self-sufficient in all its requirements of artificial fertiliser within five years.

Substitutes for scarce metals

THE demand for many metals, both imported and home-produced has recently outstripped supply. Shortages are likely to prove a problem for a great number of industries in this country. Before and during the war Germany was in the same position. The Germans were forced to find substitutes for such metals as tungsten, copper, tin, nickel and lead for a wide variety of jobs, and they were very ingenious at doing so. Information on the work they did should be of great value to British industry and a survey of German documents on research and development on substitutes for non-ferrous metals and alloys steels has been published recently for the Technical Information and Documents Unit, D.S.I.R., by the Stationery Office (1s. 6d.).

The survey consists of short summaries of the more useful papers and is made up from intelligence reports and captured German documents. The sections covered by the survey are

(1) Substitute materials for bronze and white metal bearings.

(2) Substitute materials for electric cable covers and sheaths.

(3) Alloy steels developed to avoid the use of metals in short supply.

(4) Surface coatings for steel, especially those which can replace tinning or galvanising.

(5) General substitution and new manufacturing processes developed to conserve scarce materials.

(6) Food cans and containers developed to avoid the use of tin.

(7) Substitutes for tungsten in sintered carbides for tipped tools and dies.

(8) Steel cartridge cases (to replace brass).

Certain categories of reports are written in English and can therefore be of immediate assistance. Most of them can be obtained in the ordinary way from the Stationery Office. Some which are out of print or have not been published can be obtained on application to the Technical Information and Documents Unit, London, W.C.1. Photocopies of German documents can also be obtained from T.I.D.U.

British gas turbines

A BROAD outline of the history and development of Britain's gas turbine industry and an indication of the research work at present being carried out is given in 'The Story of the British Gas Turbine,' a brochure, compiled by Power Jets Ltd., in co-operation with 15 leading manufacturers in the industrial gas turbine field. The fundamentals and advantages of the gas turbine are described as well as the co-operation in research matters between different countries. Details of metallurgical investigations into high-temperature-resistant steels are included. Research work on heat exchangers, one of the most important units in gas turbine installations, is being carried out by a number of companies. The gas turbine of the future will find a use for both recuperative and regenerative heat exchangers, the former more in the stationary field as at present, and the latter in the field of traction and possibly in that of aircraft. Designs are still in the development stage and novel heat exchangers can be expected within the next year or two. A study of the principles of combustion and combustion systems, together with the necessary technique for their manufacture in the special heat-resisting materials is referred to as well as the development and manufacture of high-pressure fuel supply and control systems. Information is given about the nine different British companies manufacturing gas turbine units as well as the Government research departments.

The information and illustrations given in this 40 page brochure show that British engineers are well to the fore in gas turbine design, production and application. Moreover, the programme of far-sighted and co-ordinated research will ensure that this position is maintained in the future.

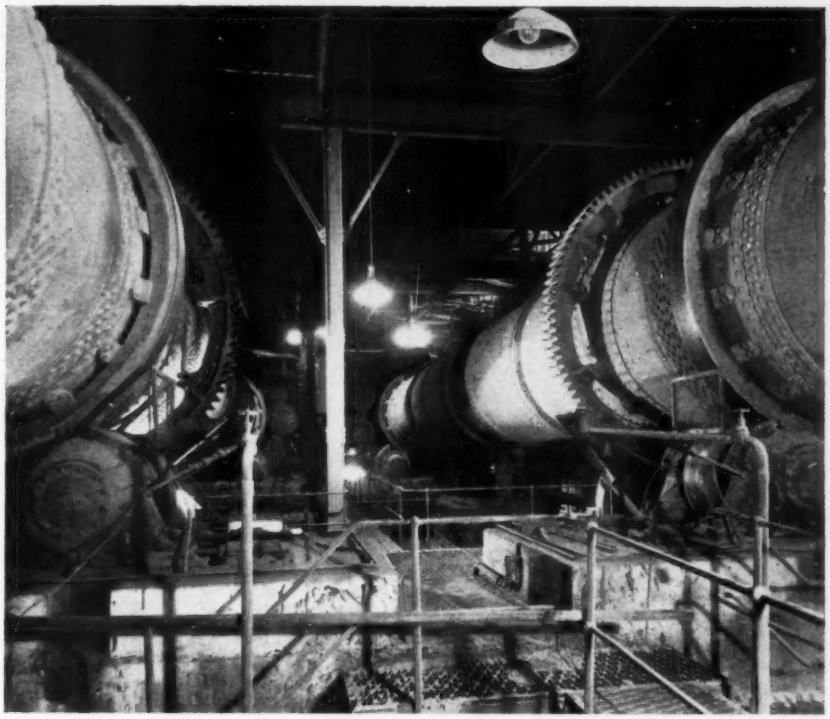
Acetylene from Hydrocarbons

By J. W. Woolcock, B.A., B.Sc., Ph.D.

Calcium carbide, the usual raw material for acetylene manufacture, requires great quantities of electricity for its production. This, in turn, requires considerable amounts of coal, except where water power is available to generate electricity. As part of the general trend to economise in the use of increasingly costly coal in chemical manufacture, processes have been devised for the production of acetylene from gaseous and liquid hydrocarbons. Here is a brief review of these processes as read at the Jubilee Meeting of the British Acetylene Association held in London recently.

IT is possible to sense that there is at this time a rapid intensification of interest in the production of acetylene from sources other than carbide. There have appeared in the last year a number of interesting articles devoted wholly or partly to this question. There are reports from the U.S.A. that a plant is to be built for one such process. I have no means of verifying these reports, but I believe that here we have a first indication of a very important trend.

Chemical technology, in developing chains of syntheses, is very concerned to send out new shoots and branches where they will bask in the sun of the approval of the purchasing public, but it must also concern itself constantly with its roots. Old roots may find themselves adversely affected by the great sociological changes of our time and particularly by the trends in the services which men will agree to perform and the value set upon them. The mining of coal by human labour under the conditions and for the real or relative wages prevalent a quarter of a century ago is, in civilised countries, a thing of the past. The price of coal has increased out of all proportion to the increase in the general price levels of industrial chemicals. From the cost point of view, carbide is coal plus electricity, and except under the rare condition where all the electricity required in the country is made from water power, additional electricity for chemical purposes requires, in fact, more coal. Apart from the cost aspect, the amounts of coal and electricity we should like to see available in the United Kingdom at this time exceed the supply ; while vast schemes are afoot to mitigate this situation, it would appear to be desirable to avoid mortgaging in advance new coal-getting and electric power capacity, if it can reasonably be avoided. Already the price mechanism has enforced economy to the extent that where the mechanical end-product desired can be made equally well from carbide via acetylene or from some other raw material such as molasses or oil (with ethyl alcohol, ethylene or propylene as intermediates), there is a general trend away from the acetylene route. But it is perhaps significant that we find that acetylene based on methane appears to us to be starting to compete with ethylene derivatives as raw material for acrylonitrile.



Two of the lime kilns at the Port Talbot (Glamorganshire) calcium carbide plant of British Industrial Solvents Ltd.

However, the general problem centres on those chemicals for which it is essential or highly desirable to use acetylene as raw material, as, for example, in the field of plastics (vinyl chloride), synthetic rubber (*Neoprene*), and chlorinated solvents (trichlorethylene). Will these be extended on the basis of carbide or on some other basis? It is impossible to give a short answer to this question but I can indicate what possibilities exist and what their characteristics are.

TABLE 1. ACETYLENE MANUFACTURING PROCESSES

Process	*Raw materials*	*Method*	*KWH/ton C_2H_2 as electric power*	*Pressure of operation*
Carbide	Coke, lime	Electric furnace	11,000	Atmospheric
Huls	Methane or methane - ethane mixtures	Electric arc	13,000	1.5 atm. abs.
Schoch	Hydrocarbon gases or light oils	Electric discharge	10,000	Atmospheric
Sachse	Saturated hydrocarbon gases + O_2	Partial combustion	400	Atmospheric
Wulff	Gaseous or liquid hydrocarbon	Regenerative furnace cracking	7,000	Less than atmospheric, approx. 0.1 atm. abs.

Operating conditions

The processes listed in Table 1 all operate at high temperatures of the order of 1,200 to 1,800° C., because acetylene is an

endothermic compound and the equilibria in the reactions by which it is formed are only favourable at high temperatures. At the temperature of its formation acetylene tends to decompose to carbon and hydrogen and/or to polymerise to benzene when the concentration of acetylene becomes high. These two facts necessitate rapid quenching from the reaction temperature and tend to produce acetylene rather heavily diluted with other gases. Quenching is scarcely compatible with good heat economy and the enrichment of acetylene to the high concentration so easily obtained using carbide raises problems of its own and entails additional cost, unless, of course dilute acetylene can be used.

Individual processes

Turning now to the individual processes, one can regard the Huls process as a typical one in the tradition of Birkeland-Eyde or Schonherr, whose furnaces were early used for the rather similar problem of causing nitrogen and oxygen to react to oxides of nitrogen as a means of fixing atmospheric nitrogen. It will be seen that the electric energy requirement is, if anything, rather higher than that of the carbide route. The Schoch process aims at lower power consumption by using a rotating earth electrode, which reduces the time of contact at a high temperature ; it can be used with hydrocarbon gases or vapours of light hydrocarbon oils as feed material. These two processes operate at or near to atmospheric pressure. The use of the electric arc gives a brief moment of very high temperature followed by rapid quenching by dilution ; ionisation phenomena within the arc probably also play an important part. It is to be noted that both processes use, essentially, electric power.

The Wulff process can be made to give acetylene and ethylene together ; this raises certain difficulties if both acetylene and ethylene have to be separated in a pure condition. The high temperatures are achieved by a 'make and blow' system, similar to that used in making water gas ; the heat of the combustion or 'blow' period is stored by chequer work for the 'make' or cracking period. In view of the lower temperatures and lack of inherent quench, a pressure of only about $\frac{1}{10}$ of an atmosphere has to be used and the machinery used to get this vacuum consumes considerable energy ; there is also the problem of making the furnace gas-tight. Finally there is the Sachse process depending on the partial combustion with oxygen of methane or ethane followed by water quench. The burner gas contains 9% acetylene by volume and after this has been scrubbed out the residual mixture of carbon monoxide and hydrogen can be made suitable for ammonia synthesis. The energy balance is not very good but it is not essential to use much electrical energy.

Conclusions

In so far as pure acetylene is required, each of the above processes has to include an enrichment step. Relatively little has been disclosed on this subject. Progress which it may be possible to make in improving the heat economy of each of the above processes may well be decisive for its success. Since carbide is easier to transport than acetylene, one may assume that carbide will hold its place for supplying acetylene to existing acetylene-using plants where the scale of use in any one place is not large. The alternative processes will find optimum conditions where, in one place, there are (*a*) ample supply of raw material, (*b*) a large use of acetylene already existing or being created, and (*c*) favourable conditions for the disposal of the gaseous by-products formed.

Sea-water Cooled Natural Gas Plant

A PLANT which converts natural gas into a gas closely approximating water gas has recently been built by the Long Island Lighting Co., U.S.A., using a new method of tapping sea water as a cooling medium. The plant has a capacity of 35,000,000 cu.ft./day of natural gas, which after catalytic cracking is enriched and stored. The plant and cooling system are described in *Chemical Engineering Progress*, 1951, **47** (5), p. 21.

The two basic cooling jobs are to cool the recirculating scrubbing liquor and the fresh water which is circulated in the jackets of the gas compressors and their prime movers. The equipment used for cooling all recirculated fresh water consists of built-up batteries of cast-iron cooling section over which salt water is sprayed from the harbour. The cooling sections are made of highest-grade cast iron and have high resistance to salt-water corrosion. The coolers, designed for a minimum of evaporative cooling in order to avoid salt incrustation, are placed close together and are surrounded by *Transite* walls. The walls prevent salt mist from being blown over other corrodable structures made of carbon steel.

The scrubbing liquor cooler is arranged in three banks, each serving scrubbers for one of three surface combustion cracking furnaces. There are 418 sections in each bank, which has two rows of sections in series, each row consisting of 11 parallel stacks, 19 sections high. The three banks are also interconnected. The combined cooler with 1,254 sections was designed to cool 1,800 gal./min. of scrubbing liquor from 140 to 95°F. when supplied with 2,325 gal./min. of sea water at 70°F.

The cooling water in the compressor and engine jacket system is similar to that for scrubbing liquor. There are five compressors. Two, which are are driven by 2,000-h.p. natural gas engines, are each provided with a cooler consisting of 256 sections arranged in parallel, 16 sections high. They cool 550 gal./min. of jacket water, using 633 gal./min. of sea water at 70°F. The latter three units, electrically driven, are cooled by 208 sections arranged in 13 parallel stacks, 16 sections high. These sections cool 630 gal./min. of compressor jacket water from 113 to 90°F., using 550 gal./min. of sea water.

Jacket water for the two gas engines is cooled in 11 parallel stacks, 10 sections high. Sea water flows over these cooling sections at a rate of 420 gal./min. to lower the temperature from 162 to 150°F.

Recent publications

Evaporating plant. Vertical short-tube evaporators, forced circulation evaporators, thermo-compression evaporators, salting evaporators, multiple-effect evaporators and special evaporators are described in Bulletin No. 114 recently issued by George Scott & Son (London) Ltd. Most of the Scott evaporators work with the heating surface completely or almost submerged in the liquor. However, there are special cases where film evaporation is of value, for example, in the dehydration of various organic chemicals. Auxiliary equipment, including condensers, vacuum pumps, entrainment and frothing separators, pre-heaters and controls is also described.

Chemical apparatus. One hundred and twenty-five years of chemical apparatus and instrument manufacture is described in a souvenir catalogue published by Griffin & Tatlock Ltd. The making and selling of chemical and physical apparatus began in 1826 as a department of Richard Griffin & Co., a publishing and bookselling business in Glasgow. In 1926 the company amalgamated with Tatlock's business in Glasgow and Manchester and became Griffin & Tatlock Ltd. Today a very wide range of apparatus is manufactured to meet the needs of industrial, research and educational works engaged in all kinds of chemical and physical investigations.

Conveyor belt maintenance. The prompt repair of cuts, chafed spots, gauges and snags in conveyor belting will repay in extra life and tonnage delivery, for such wounds leave the way open for grit and moisture to penetrate and damage the duck until the belt is seriously weakened. A booklet published by the British Tyre & Rubber Co. Ltd. gives details of their mobile belt repair service as well as the maintenance equipment and accessories supplied to enable the man on the spot to carry out repairs that will protect the belt carcase until a vulcanising repair can be made.

Saving Sulphuric Acid in the Fertiliser Industry

Specially contributed

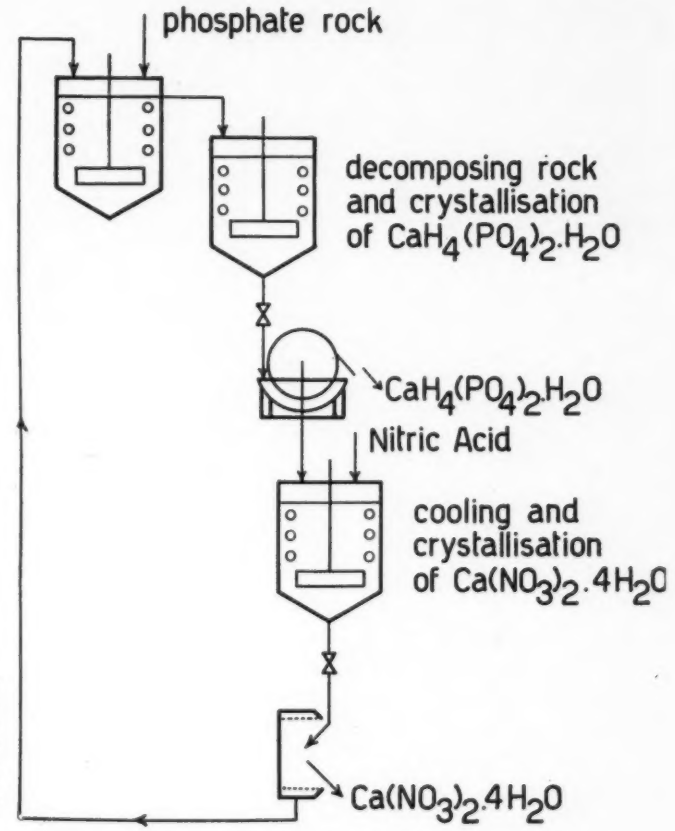
Although sulphur as such is little used in fertiliser manufacture, huge quantities are required in the form of sulphuric acid. Thus, at the present time of sulphur scarcity, it is natural to consider what savings can be made by the biggest single consumer of sulphuric acid. In this article, after an examination of the various suggestions made, it is concluded that the main technical opportunities for saving acid are in superphosphate manufacture. Another, and simpler means of acid economy, it is argued, is the replacement of the present standard of water-solubility for superphosphate by one of citrate-solubility.

IN making superphosphate, sulphuric acid is very heavily consumed. About 11 cwt. of 68-70% acid is needed to make 1 ton of superphosphate. In 1948/49, U.K. output (according to the Commonwealth Economic Committee's last Report) was 1,127,000 tons. This is equivalent to 620,000 tons of acid of the strength mentioned above. Since then there has been some expansion in production. At least one triple superphosphate factory has been erected, and this had originally been planned to use acid made from sulphur. It is conservative to assume that our phosphatic fertiliser needs would amount to at least 650,000 tons of acid. The intensification of fertiliser use on grassland would, of course, increase this figure considerably.

Sulphate of ammonia

The other acid-consuming process of the fertiliser industry is the manufacture of sulphate of ammonia. Here acid is a convenient agent for converting ammonia gases and liquors into the sulphate. It is often suggested that this process is an even heavier consumer of acid than the superphosphate process. A superficial (and inaccurate) view of the statistics for nitrogenous fertiliser production seems to show this. U.K. production in 1948/49 was 996,000 tons of sulphate of ammonia. *If* all this production had been based upon acid, this would have involved a consumption of 750,000 tons of acid (100%) or about 1,100,000 tons of 68-70% strength, that is to say, nearly twice the acid usage of the superphosphate branch of the industry.

Fortunately the use of sulphuric acid has long been avoided in much of our sulphate of ammonia production. Ammonia made by the synthetic or air fixation process is not absorbed by acid to convert it to sulphate. At I.C.I.'s Billingham works it is converted into ammonium carbonate by direct treatment with carbon dioxide ; the ammonium carbonate solution is then mixed with mineral calcium sulphate. Thus, advantage is taken of the greater insolubility of calcium carbonate (which is precipitated) to leave ammonium sulphate in solution. This process has been particularly effective at Billingham for the works contains its own deposits of calcium sulphate. (The by-product calcium carbonate is used for *Nitro-Chalk* manufacture).



Flowsheet of Dutch experimental process for the production of monocalcium phosphate by nitric acid treatment.

If we make the broad assumption that all by-product sulphate of ammonia uses acid and that all synthetic production is based upon calcium sulphate, we can arrive at an approximate estimate of the total amount of sulphuric acid required by this branch of the fertiliser industry. In 1949 by-product ammonium sulphate was made at 101 plants which made a total of 288,200 tons. Rounding off these figures to allow for some expansion since 1948, the picture is as follows :

	tons
Total sulphate of ammonia production	1,000,000
By-product sulphate of ammonia	300,000

This suggests that the acid requirements are 225,000 tons (100%) or about 320,000 tons at 68-70% strength, roughly one-half of the acid usage in superphosphate production and even this estimate is likely to be too high.

A further point should be mentioned in the matter of sulphate of ammonia. Britain produces about a quarter of her sulphate of ammonia for export. It would be unjust, therefore, to look upon the total

sulphuric acid requirement of this branch of the industry as a demand made by the needs of British agriculture.

Synthetic ammonium nitrate

There does not seem to be any sulphur economy to be found in producing more synthetic ammonium nitrate (using nitric acid derived from ammonia oxidation) and less synthetic sulphate of ammonia. Recent plans to expand *Nitro-Chalk* production are desirable simply because *Nitro-Chalk* is often a better fertiliser for grassland. Where strong sulphuric acid is used in by-product ammonia saturators, there is certainly some case for its replacement by nitric acid. Against this, however, must be placed the fact that by-product sulphate of ammonia is made at a large number of works, many of them small, and ammonium nitrate is not a satisfactory fertiliser unless it can be conditioned by conversion into *Nitro-Chalk* or packed in steel drums. The conversion of small sulphate production units into ammonium nitrate units would be cumbersome and costly.

Gas-works ammonia liquors

Recent field experiments in Britain, Germany and France have shown that ammonia liquors from gasworks can be satisfactorily used as direct fertilisers for farming. Where a small gasworks is close to a farming area, this could be developed. In 1929 there were 450 plants producing by-product sulphate of ammonia, but by 1948 the figure had fallen to 101. This is an indication that the type of works which might develop a localised fertiliser trade in ammonia liquor is, in fact, a gasworks not now producing sulphate of ammonia at all, and that the works which are still producing by-product sulphate are mainly the bigger works sited in industrial and congested areas not conveniently adjacent to farms. It seems unlikely, therefore, that this development can lead to much economy in the use of sulphur or sulphuric acid.

Superphosphates

It is clear that the main opportunity for saving sulphur in the fertiliser industry is to be found in the superphosphate branch. Here sulphuric acid is used as a chemical agent for breaking up the phosphate complex of mineral rock phosphate. It is already well known that nitric acid can be used in place of sulphuric acid. In Germany as early as 1930 nitric acid methods had been successfully employed; in France methods using mixtures of nitric and sulphuric acid were developed early in the post-war period; the Netherlands State Mines have also introduced a mixed-acid process. Nitric acid methods require a final neutralisation of the acidulated product; ammoniation is an obviously attractive step to achieve this. An important disadvantage of the nitric acid treatment is that it produces calcium nitrate as well as soluble calcium phosphates. As a fertiliser material calcium nitrate is most undesirable; it readily absorbs moisture and therefore lacks good storing properties. The use of sulphuric acid and nitric acid as conjoint agents for breaking up the rock phosphate complex overcomes this problem because there is a sufficient formation of calcium sulphate to protect the calcium nitrate from its hygroscopic tendencies. Recent pilot-scale research by the Chemical Research Laboratory (D.S.I.R.) has shown that a 4: 3 mixture of nitric and sulphuric acids produces a relatively non-caking, dry-storing 'superphosphate.' Such a fertiliser, of course, contains nitrogen as well as phosphate. This work is similar to post-war work in France and Holland. Small-scale production of a nitro-phosphate has already been announced by Imperial Chemical Industries Ltd. In this process nitric acid and rock phosphate are mixed in a corrosion-resistant steel vessel; calcium di-hydrogen phosphate and calcium nitrate are produced. Further treatment with both ammonia and ammonium sulphate converts the undesired calcium nitrate into ammonium nitrate and calcium sulphate.

Thus there are two approaches to the successful use of nitric acid. The use of nitric acid alone can be followed by ammoniation to overcome the problems of acidity and calcium nitrate hygroscopicity. But here the initial acid treatment requires different plant from that commonly used in superphosphate manufacture. The use of nitric and sulphuric acid mixtures is said to overcome the problem of final condition, and this type of process can be carried out in the plants normally used for superphosphate.

The I.C.I. nitro-phosphatic fertiliser has an analysis of 15.4% *total* P_2O_5 with 12.7% citric-soluble, and 12.7% nitrogen. Various products were prepared in the C.R.L. research, but one likely analysis for large-scale development would seem to be: 18% P_2O_5 and 17.5% nitrogen.

Disadvantages of nitric acid processes

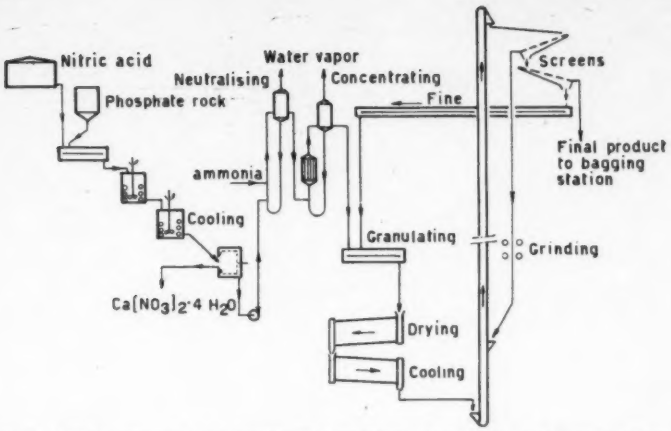
It is necessary to be cautious in acclaiming these processes as easy ways of economising in sulphur. The product of the century-old superphosphate process is a simple phosphatic fertiliser. The product of these total or partial nitric acid processes is also high in nitrogen content, and nitrogen is not a particularly cheap plant-food. Many farmers use superphosphate as a single dressing for crops, relying upon manures and rotated leguminous crops for much of their nitrogen requirements. They will not want, nor be willing to pay for, so much nitrogen in association with phosphate. Moreover, the nitrogen is in nitrate form, a quickly active and easily leached form. The time when phosphate is needed in crop development (particularly cereals) is early; the time when nitrate nitrogen is required is later. Heavy rain after combine-sowing seed and fertiliser would not wash out the phosphate but it would certainly wash out a good deal of the nitrate-nitrogen before the crop had grown sufficiently to assimilate it. Ammonia-nitrogen "stores" better in the soil. If these nitro-phosphatic fertilisers are to be developed, they are more likely to take the place of *concentrated* nitrogen-phosphate fertilisers whose production has previously required sulphuric acid to provide the soluble phosphate content. And this is a limited displacement of our normal phosphatic fertiliser usage.

If this forecast is true, it carries a natural corollary; the addition of potassium will be generally needed as most concentrated fertilisers of this kind have in the past been complete NPK suppliers. It must not be forgotten that the great virtue of the superphosphate process is that it produces an active phosphatic fertiliser and nothing else; and many British soils are fertilised with priority attention to their phosphate needs, the additional supplies of nitrogen and potash being smaller in proportion and often adjusted according to the farmer's estimate of needs in any particular season. This may or may not be technically sound; strong arguments can be advanced to show that more nitrogen should be used in such cases. But it is often a farmer's view of his soil needs and increasingly it is likely to be his *economic* view of the investment he can risk in fertiliser applications.

The fluorine problem

Another consideration that suggests caution is the non-removal of fluorine when nitric acid is used to treat rock phosphate. It is sometimes suggested that the main cause of "inactivity" in mineral phosphates is their fluorine content; thermal de-fluorination has produced phosphatic materials that give field-results equal to those of superphosphate. In the sulphuric acid reaction, there is a satisfactory removal of fluorine. There is the possibility that the phosphate content of nitro-phosphatic fertilisers may be less efficient in the soil than that of superphosphate made from sulphuric acid. Field-tests have yet to dispose of this point. Also, the fluorine problem may become a restriction upon the choice of phosphate rock, grades with higher than moderate fluorine contents being undesirable. They have always been less desirable for the sulphuric acid process but it has nevertheless been possible, when unavoidable, to use them and produce a satisfactory superphosphate.

Fusion processes remove fluorine and produce satisfactory phosphatic fertilisers, but the economics of these processes make them rather unattractive. The high temperatures required present substantial plant maintenance problems and flux materials to reduce the fusion temperatures present chemical problems that would impair the final efficiency of the fertiliser. It seems unlikely that fusion processes will be developed in Britain *unless* the sulphur situation deteriorates before alternative methods of producing acid have been sufficiently developed. Cheap fuel and/or



Flowsheet of Dutch process for making di-calcium phosphate and ammonium nitrate simultaneously. Ammonia is used as neutralising agent. This process is commercially operated by the Dutch State Mines, producing a material with 20.5% N and 20% citrate-soluble phosphoric acid.

(This flowsheet and that on page 419 are from the paper: 'Theory and Practice in the Treatment of Phosphate Rock with Nitric Acid' by Dr. M. H. R. J. Plusjé, and are reproduced by permission of the Fertiliser Society)

power are obvious requirements for fusion processes. The problem of power cost similarly obstructs the development of electric furnace approaches to the production of phosphoric acid; a primary foundation for such processes is an abundance of cheap power. Lacking this, the British plans to produce triple superphosphate have been based upon the 'wet process,' which is an extension of the superphosphate process and requires sulphuric acid.

It must be expected then, that superphosphate will continue to be required in considerable quantities. The nitric acid substitution processes will make special rather than general inroads into the normal demand for superphosphate. Further economy in the use of sulphuric acid must be looked for in the superphosphate process itself. Less attention would seem to have been directed to this possibility yet it could be more speedily helpful than processes that require either new plant or technical education of farmers to accustom them to entirely new fertilisers. Need so much acid be used to produce each ton of superphosphate? A small saving of acid per ton of product would add up to a substantial tonnage of acid, perhaps more than the tonnage likely to be saved by replacing a proportion of superphosphate production with nitro-phosphate types.

Citric-solubility

In Britain superphosphate is legally tied to the standard of water-solubility; in a number of other countries, including the United States, the standard is one of citric-solubility. Our Fertilisers Act has been unchanged since 1926. It must be regarded as an antiquated piece of legislation, long left behind by technical progress. Less acid per ton of superphosphate is required to produce citric-soluble phosphate. To quote from the report of the British Productivity Team which visited America in late 1949: 'The advantage of the available phosphoric acid standard . . . was clearly seen in the lower acidulation of phosphate . . . giving a much drier and more friable product than is obtainable in this country and still having the same plant food value.' Figures given as typical for U.S. superphosphate production in this report (after allowing for the smaller ton in the U.S.A.) show that superphosphate containing 17% water-soluble plus 3% available P_2O_5 (*i.e.* 20% total) requires about 11 cwt. of 122° Tw. acid. Admittedly this seems equivalent to the figure of 11 cwt. of acid already given earlier, but this British figure was based upon processing details for 16% water-soluble superphosphate (Gray: 'Phosphates and Superphosphate'). It is difficult to assess the degree of acid economy that would be possible by discarding the water-soluble criterion, but it certainly is indicated that the same usage of acid could produce more available phosphate, and it would be a conservative conclusion to say that 10% of the acid now used could be saved. It might be noted in this connection that the nitric acid phosphate products declare their content of P_2O_5 as citric-soluble.

Other sulphur-saving benefits of a change in our legal criterion for phosphoric acid would be achieved. The use of liquid ammonia or ammonia solutions as a source of nitrogen in making compound fertilisers is much practised in America; here it cannot be done as it reverts the water-soluble phosphate. By-product sulphate of ammonia which has been based upon acid in its manufacture could be at least partially replaced by ammonia. However, this economy would require plant changes in compounding works; it could not be as rapid an economy as the saving of acid directly used in making superphosphate.

Whether or not we face this change now as an emergency move to combat the current sulphur situation, we shall be obliged to face it later. Within two years alternative methods of producing acid may have compensated for our losses in acid production based upon American brimstone. But this acid will be dearer, particularly the acid derived from anhydrite. There is an economic limit to fertiliser costs. To keep fertiliser prices in line with the pattern of farm produce prices, economies in the use of acid to make phosphatic fertilisers will be forced upon manufacturers. This being inevitable, it seems far wiser to start making the change at once. What objection is there to an emergency amendment of the existing Fertilisers Act, an amendment that recognises the possibility of citric-soluble or citrate-soluble phosphate?

Gelatin in the photo industry

PHOTOGRAPHY has only been able to develop to the extent it has and show the versatility it possesses, because of the remarkable suitability of gelatin as a binding and protecting medium. This was the view of R. C. M. Smith, F.R.I.C., F.R.P.S., of Ilford Ltd., speaking at the Third Research Panel of the British Gelatine and Glue Research Association. The properties which make it so suitable are its suspending power, its gelling property and the ease of reversible conversion from sol, its ability to permit the diffusion of water and aqueous solutions through it, and the swelling which accompanies diffusion, the ease with which it can be softened or hardened by simple additives when the process demands it, and its property of modifying photographic sensitivity.

Its function as a protective colloid in maintaining the state of dispersion of the silver halide has been investigated by Sheppard and his co-workers in the Eastman Kodak laboratories. They have been able to show that gelatin is powerfully adsorbed on silver bromide, and that when a monolayer has been formed the surfaces are hydrophobic, presumably because of the orientation of the adsorbed molecules. This results in flocculation and precipitation of the dispersion. At higher concentrations of gelatin, however, a second layer is adsorbed, and the surface becomes hydrophilic. At these concentrations of gelatin, the silver bromide is repeptised.

The sol-gel transformation is probably caused by the partial orientation and cross-linking of the molecules under the influence of interchain polar forces and of N—H—O hydrogen bonds which become effective at lower temperatures.

Diffusion of inorganic ions through the gel is of great importance, since it renders possible the washing out of unwanted materials and by-products during manufacture, and the aqueous processing of the exposed film.

A great deal of work has been done on the influence of gelatin on photographic sensitivity, and the nature of 'natural' sensitisers, but there is still much to be learned and applied.

MIXING

Power consumption, heat transmission and gas absorption

By D. F. Riley, B.Sc., A.C.G.I.

SINCE the last review on mixing appeared in this journal (October 1950), the published literature has included papers on the power consumption of the principal types of liquid agitator, on agitated gas absorbers, and on the relation between agitation and heat transmission.

Power consumption

Comprehensive data on the power requirements of propellers, turbines and paddles obtained in the research programme of a leading American manufacturer of mixing equipment are reported in two papers by Rushton, Costich and Everett.[1] These data are of exceptional importance because the range of operating variables covered is wide enough to include installations of industrial size. Experiments are described in which impellers of various shapes and sizes were run in different positions in tanks from $8\frac{1}{2}$ in. to 8 ft. diameter, containing liquids having a very wide range of viscosities and densities. The usual equation for the power function or drag coefficient

$$\psi = \frac{P}{\rho N^3 D^5}$$

in terms of the Reynolds number

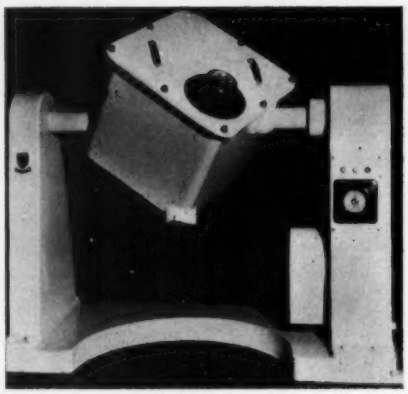
$$\mathrm{Re} = \frac{D^2 N \rho}{\mu}$$

and the geometrical ratios of the system, is derived by dimensional analysis, but this has been widened in scope to include the Froude number

$$\frac{DN^2}{g}$$

which is involved when there is standing wave formation as in an unbaffled tank. In the above dimensionless groups P = the power consumption, D = the impeller diameter, N = the impeller speed, ρ = the liquid density, μ = the liquid viscosity and g = the acceleration due to gravity.

When running a 12-in. diameter three-bladed marine propeller in a 54-in. diameter unbaffled tank it was found that there was little vortex formation at Re< 300, but that at higher speeds the vortex formed rapidly. The exponent of the Froude number in the equation for the drag coefficient was found to depend on the Reynolds number and on the ratio of propeller diameter to tank diameter. It was shown that the curves of power function ψ *versus* Re for any impeller in a baffled tank could be approximated by plotting only three values, namely at Re = 5, 200 and 10^5. A line of slope equal to -1 is drawn through the point Re = 5 and one of zero slope through Re = 10^5, and these are joined by a curve passing through the third point. The value Re = 200 was selected because this is approximately the point at which the power function is a minimum under fully baffled conditions.



[*Photo: Foster, Yates & Thom Ltd.*

Double-pedestal, transportable, industrial mixer. The mixing container is a cubic drum mounted diagonally on trunnions and rotated quite slowly to produce a mixing action which resembles a 'figure of eight,' or interweaving motion. The method of mounting and rotating the drum completely eliminates 'dead spots.' No complications arise through centrifugal forces, and the mix is protected against harm arising from either attrition or pulverising. Impellers can also be used when mixing ingredients that will not readily flow or have a tendency to clog and thus, in addition to the 'figure of eight' motion, the mix is gently turned over itself, which in many instances speeds the mixing action and counteracts any tendency to 'balling.' The machines can be supplied in sizes ranging from 10 lb. charging capacity up to 15 cwt. at S.G.I, and the mixing containers are available in stainless steel, aluminium or mild steel. Other materials or linings can be quoted upon request. Great care has been taken with the lubrication system, all bearings being adequately sealed to prevent contamination of the mix. The ease with which the mixing container can be completely cleaned is another feature. On the transportable model above, all electrical equipment is built in and completely enclosed, and a 'three push-button starter' giving inching control is fitted on all types.

Experiments carried out with propellers in unbaffled tanks showed that as the speed was increased both the power consumption and the depth of vortex increased until the latter was equal to the depth of immersion of the propeller. At this speed air was drawn into the propeller and the power requirement accordingly decreased. Turbines varying from 3 to 48 in. diameter were tested, and curves of drag coefficient ψ *versus* Reynolds number Re obtained for baffled and unbaffled conditions which were similar to those already described for propellers. From the shape of the curve for a flat-bladed turbine running in a fully baffled tank, it is clear that the viscosity can vary over a very wide range without affecting the power consumed. The square pitch marine propeller, the 45° pitched blade turbine, and the shrouded turbine with stator or wall baffles display the same characteristic over a much smaller range of viscosities.

The ratio of tank diameter D_T to impeller diameter D was found to have no effect on the power drawn by turbines and propellers in baffled tanks within the usual range of sizes. In the absence of baffles, however, the power drawn by propellers was proportional to

$$\left(\frac{D_T}{D}\right)^{0.91}$$

over the range

$$\left(\frac{D_T}{D}\right) = 2.7 \text{ to } 4.5 \text{ at } \mathrm{Re} = 10^5.$$

No data were obtained in which liquid depth or the clearance of the impeller from the bottom of the tank was the only variable. The experiments did provide, however, the first significant data on the effect of propeller pitch p on the power consumption, which showed that over the range

$$\left(\frac{p}{D}\right) = 1.0 \text{ to } 2.5$$

the power drawn was proportional to

$$\left(\frac{p}{D}\right)^{1.7}$$

Data are also given in the original papers for the effect of the number, length and width of blades on the power requirement of a turbine impeller, though these factors were not all varied independently.

Since 1934, when White and his colleagues published their work on the power consumption of paddle agitators, it has become customary to present such data in the form of curves similar to those used by Stanton for fluid friction data. The power function or drag coefficient is plotted

as a function of the modified Reynolds number, and the resultant curves are of the form shown in Graph 1. From this graph it is clear that there is a value of the Reynolds number in the streamline region, a value which may be called the transition point, at which the power function equals that for turbulent flow under baffled conditions, and that this transition point will depend on the number and proportions of the impeller blades.

D. E. Mack, in a recent paper[2], has calculated the transition points for turbines having from 2 to 16 vertical blades welded directly to the shaft with a blade width of $\frac{1}{2}$ to $\frac{1}{10}$ the impeller diameter, from equations developed experimentally by O'Connell and Mack. He has plotted these points in the form of a grid on ψ/Re co-ordinates, so that for any simple turbine a horizontal line drawn through the appropriate transition point gives the drag coefficient in the fully baffled condition, and another line with a slope equal to —1 gives the coefficient in the streamline region. The only part of the curve for the given turbine which is not obtainable directly by this method is that which lies in the transition region of flow, and this is of no great importance, since the power consumption in this region is less than in either streamline or turbulent flow. The method described in Mack's paper does not apply to propellers or to unbaffled turbines, as the shape of the ψ/Re curve is quite different under these conditions.

Heat transmission

The application of agitation to improve or control rates of heat transmission is a feature of the design of several types of chemical plant, including evaporators, crystallisers, reaction vessels and brine tanks. Where heat transfer is the only consideration, the agitation is designed to secure as high a film coefficient on the inside of the vessel as is economically possible. More often, however, there are other conflicting requirements to be met, such as the mixing of liquid components, the dispersion of immiscible liquids, suspension of solids or absorption of gases, and in these cases a compromise has to be made between maximum intensity of agitation and maximum rates of heat transfer.

This powder mixer is available in six models with trough capacities of 2, 4, 6, 8, 10 and 20 cu. ft., and the construction is of either stainless steel, Monel metal or mild steel. The internal shaft on which the agitators are mounted is carried on special bearings and sealed to prevent leakage from or into the trough. In addition to the mixing action, the agitators direct the mixing to the discharge outlet, making the mixer self-emptying. The mixing capacity of any model depends upon the bulk density of the powders to be mixed. For example, a batch of 1,000 lb. of material having an average bulk density of 50 lb./cu.ft. requires a mixer with a trough capacity of 20 cu. ft., whereas a batch of 1,000 lb. average bulk density 100 lb./cu.ft. requires a mixer with a trough capacity of 10 cu. ft.

[Photo: Pascall Engineering Co. Ltd.

The type and size of agitator required will depend on such factors as the density, viscosity, specific heat and thermal conductivity of the components, the fouling tendency of any solids present, and whether a jacket or coil is used as the heat transfer surface. The layout of a heating or cooling coil in an agitated vessel requires careful consideration in relation to the agitator and baffles, and should be arranged so as to promote free circulation of the liquid over the whole of the surface.

Cummings and West[3] present experimental data on heat transfer coefficients in a 30in. diameter steam-jacketed vessel, fitted with a 24in. diameter helical cooling coil. In most of the work two 12in. diameter 6-bladed radial flow turbines having retreating blades were used, while in others, a single 12in. diameter 6-bladed 45° pitched turbine was adopted, producing flow with both axial and radial components. No baffles were provided in the vessel, and a gap was left in the coil opposite each impeller. The liquid depth for each run was equal to the vessel diameter, and three agitator speeds were used, namely, 107, 182, and 240 r.p.m.

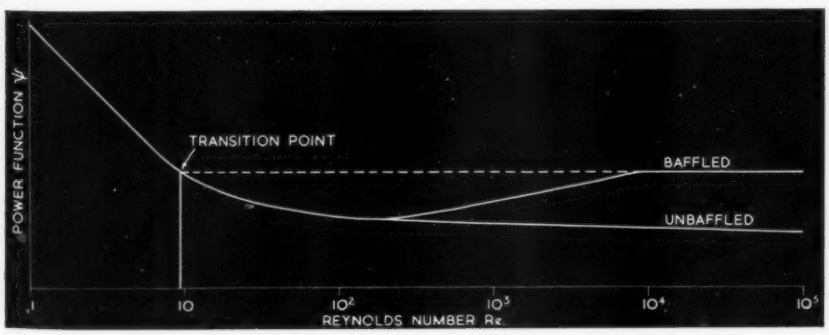
For the cooling coil, overall resistances were plotted against $\frac{1}{\mu^{0.8}}$ (μ being the water velocity inside the coil), and from these the film coefficients for the outside of the coil were deduced. For the heating jacket, the film coefficients on the liquid side were estimated from the overall coefficients by applying the standard theoretical equations to the steam side conditions. The data were correlated by means of the well-known equations of Chilton, Drew and Jebens, and gave results about 11% higher for the jacket and 16% higher for the coil than those of the earlier workers.

Gas absorption

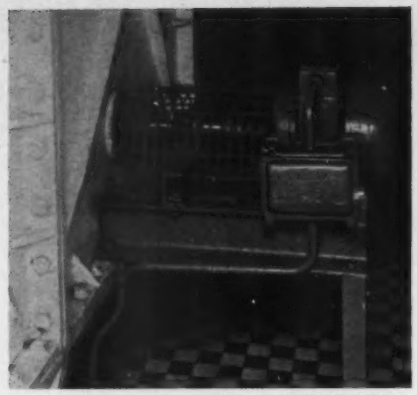
The absorption of gases in liquids is commonly effected in columns similar to those used for distillation, but these are found to be unsuitable when the third phase is present in the shape of suspended solids. The contacting of gases with liquids in the presence of solids is more readily carried out in mixing vessels provided with specially designed agitators. The preparation of bleach liquor is one of the oldest instances of this operation. More modern instances are chlorinations, hydrogenations and acetylations in the presence of a solid catalyst such as anhydrous aluminium chloride, and the oxidation of fermentable materials in the production of antibiotics.

The absorption coefficient obtained in an agitated vessel will depend on many factors, including the physical properties of the liquid phase, in particular the density and surface tension, and the degree of liquid break-up produced by the shearing action of the impeller. The layout of the vessel, with its agitator, baffles and sparger, needs to be designed with a view to obtaining the maximum degree of dispersion of the gas. The design is in some cases further complicated by the thermal change due to the reaction, necessitating the fairly rapid addition or, more usually, removal of heat.

Efficient liquid break-up requires that the impeller blades be shaped to give the maximum skin friction and eddy currents, but this means that the pumping capacity of the impeller is reduced. Paddles and propellers are seldom used for gas absorption, except where the reaction is very rapid, and the type of impeller usually chosen is the high-speed turbine with blades specially shaped for the duty. The three shapes of turbine most commonly



Graph 1.



[Photo: L. A. Mitchell Ltd.

Side-entry mixer installed at a brewery for beer rousing. The speed of agitation of these units is designed to suit particular purposes. They are suitable for fitting to the side of large storage vessels and have been supplied in sizes ranging from ¼ h.p. on small tanks for beer and spirit rousing up to units of 25 h.p. on tanks holding between 1,000,000 and 2,000,000 gal. of mineral oil. It is claimed that where side-entry units are applied correctly, they provide an efficient and compact method of agitating fluids in bulk.

used in modern agitated gas absorbers are the vaned disc, the arrowhead disperser, and the shrouded turbine with stator ring.

In order to increase the time of contact of the gas bubbles with the liquid, the height of the vessel can be made equal to two or three times the diameter, and the sparger pipe located beneath the lowest impeller. Alternatively the gas can be passed through several vessels in series, in which case they need not be made so deep, the number of stages depending on the speed of the reaction. Since an agitator will draw less power when the gas is passing, the power requirement is normally calculated for the ungassed condition. When sizing the vessel, however, account has to be taken not only of the liquid volume and the gas rate but also of the expansion due to gassing. The vessel and agitator must be carefully designed as a whole, to achieve the desired rate of absorption without foaming over or allowing gas to pass through unabsorbed and yet at the same time economically.

Fermentation vessels

A recent group of papers on the performance of agitated fermentation vessels shows that the rate of oxygen absorption in fermentation processes is closely related to the efficiency of agitation and air dispersal. Brown and Peterson[4] describe a 30-litre pilot-scale fermentor having a four-bladed pitched turbine 8½ in. diameter and a single baffle plate. Optimum aeration was obtained at a rate of 0.64 litre air/min./litre of medium and an agitator speed of 580 r.p.m. Pfeifer and his co-workers[5] performed pilot-plant experiments on the production of riboflavin by submerged fermentation, and they give limited data on the conditions of optimum agitation. A 200-gal. vessel was used, 24 in. in diameter, with a liquid depth of 9 ft., and equipped with a side-entry propeller of unspecified size and h.p., located 15 in. above the tank bottom. The maximum yield was obtained with an air rate of 0.25 and a shaft speed of 100 r.p.m.

Petty[6] states that in the production of penicillin the power consumption in commerical installations varies from 0.3 to 2 h.p. per 100 U.S. gal., depending on the design of the fermentor, the amount of aeration, and the particular culture and medium used. Experiments on the absorption coefficient for oxygen in the submerged fermentation of yeast are reported by Hixson and Gaden,[7] but the apparatus used was too small to be of any help in scaling up to industrial dimensions.

Bartholomew and co-workers[8] have made a valuable experimental study of the effect of air flow and agitation on the formation of penicillin and streptomycin by submerged fermentation. The fermentors used in this work were constructed as laboratory models of industrial-size equipment, so that the data obtained could be scaled-up geometrically and dynamically in the design of full-scale plant. They have been described in detail in another paper by Bartholomew and co-workers,[9] and each consisted essentially of a 6 in. diameter × 12 in. high *Pyrex* cylinder, fitted with four baffles ⅝ in. wide. Agitation was provided by two four-bladed flat-blade tubines, 3 in. in diameter, rotated at speeds varying from 190 to 560 r.p.m. Air was introduced through spargers of two different types at rates of 0.33 to 2 litres/min./litre of medium.

It was found that as the agitator speed was increased, there was a rapid increase in antibiotic formation up to a maximum, after which further increase in agitator speed reduced the rate of production. The rates of aeration and agitation were found to be interdependent, the power drawn by the agitator at a given speed decreasing as the rate of aeration increased. This finding is in accordance with the general behaviour of agitators in gas-liquid systems, and is to be expected, since the power consumption

[Photo: Wm. Brierley, Collier & Hartley Ltd.

This mixer can be supplied with the pan in copper (tinned or silvered, if required), stainless steel, Monel metal, nickel, Inconel, etc. It is used for processing a large variety of products ranging from cosmetics to explosives. The top drive is enclosed, and the machine is also fitted with an individual-drive four-speed motor. The steam-jacketed pan can be arranged for pressures from 5 to 150 lb./sq.in., or alternatively the machine can be supplied with single-cased jacket or gas-fired water jacket for generating its own steam. A special type thermometer is fitted to show the temperature of the batch during mixing. The bow and stirrers revolve in opposite directions, but can also be arranged to revolve in the same direction. The bow is also fitted with hinged scrapers which keep the surface of the pan free from the possibility of burning. A special arrangement is fitted to prevent any surplus lubricating oil contaminating the batch. The bow and stirrers are automatically raised out of the pan merely by pressing a lever, when the pan can be tilted for emptying. For larger sized pans a worm and tilting mechanism can be fitted. A clutch arrangement is embodied in the top drive to prevent damage should the stirrers meet any obstruction when descending. The machine is made in sizes from 21 lb. capacity up to 3 cwt. and larger.

[Photo: Lavino (London) Ltd.

A 'Beken Planetex' vertical mixer with detachable paddles and pan. The centre paddle is stationary and the other rotates around it while revolving on its own axis. The paddles intermesh and the batch is subjected to a squeezing and extending process in addition to the stirring. The paddles extend downwards to the bottom of the pan and are completely immersed in the batch. The weight of the materials helps considerably to create the necessary resistance to the tendency of the materials to flow from between the paddle blades. The mixer is claimed to be suitable for the mixing and dispersion of all materials from a stiff putty-like consistency down to a cream or powder, *e.g.* plasticising PVC, asbestos fibres with solutions, paints, distempers, pastry mixtures, zinc white in oil, tooth powders and pastes, moulding powders, etc.

is proportional to the effective density of the fluid mixture. A certain minimum power is required, however, at any given air rate, and an increased air flow cannot compensate for insufficient mechanical agitation. The design of the sparger has some effect on the efficiency, and a sintered type, with pores 5 microns in diameter, gave better results than a constricted pipe having an orifice $\frac{1}{16}$ in. diameter.

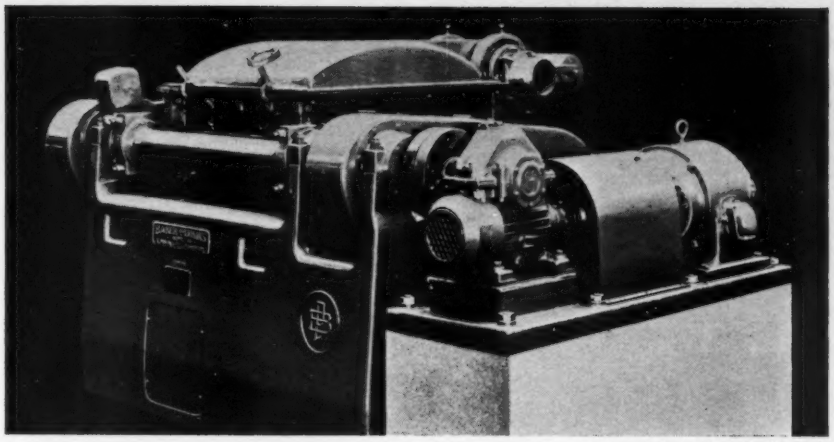
Recent developments in the design of hydrogenation equipment are described in a paper by O'Boyle.[10] An increased understanding of the role of agitation in gas-liquid reactions has led to the predominant use of high-speed turbines in place of earlier complicated circulation systems for the oil and hydrogen. A cylindrical tank is now usually adopted, with a liquid depth about equal to three times the diameter, and provided with internal coils for heating or cooling. Three impellers are required, namely one near the liquid surface, one about the centre of the liquid depth, and the third near the bottom of the tank. Hydrogen may be introduced under each of the lower two turbines, and a draught tube is sometimes provided for the top impeller, with the object of sucking back any gas which may pass through the liquid unabsorbed. The turbines may be open or shrouded, and the heat transfer surface, if located as banks of vertical tubes near the circumference of the vessel, can be used simultaneously as baffles to create optimum agitation conditions.

Dwyer and Baumann[11] and Dwyer and Burke[12] carried out a laboratory investigation into the effect of propeller agitation, among other variables, on the rate of venting unreacted isoprene from synthetic rubber latex, but the scale of operation was so small that it is doubtful whether the data obtained could safely be scaled-up to full-scale equipment.

The present position

Sufficient information is now to hand to enable the prediction of the power consumption of most types of liquid agitator to be carried out with some confidence, and attention is being turned increasingly to investigations of the factors affecting the location of agitators, coils, baffles, etc., in a reaction vessel, and to the systematic application of agitation to specific processes such as heat transfer, gas absorption or crystallisation. Further data are required on the performance of propellers when used for liquid circulation under low heads or in the side-entry location in large blending tanks. Little information has as yet been published on the discharge capacities of various impellers, and none correlating these capacities with rates of mixing.

The factors controlling the rate of dispersion of immiscible liquids, such as the



[Photo: Baker Perkins Ltd.

The latest model of the 'Universal' mixer. The mixer is tilted by a screw passing through a nut trunnioned on the underside of the trough. This screw is horizontal when the trough is in the normal working position and is operated by a geared motor bolted to one end of the front frame and connected to a bevel gear box which has totally enclosed gears running in an oil bath. Operation of the tilt is by means of push button control with 'up' 'down' and 'stop' stations. Limit switches are incorporated to control the travel of the trough in both directions. The trough is trunnioned on the front frame in which the steel mainshaft is totally enclosed. Blades are of the Sigma or 'Z' type, but other types may be incorporated for specific applications. The trough of the machine illustrated is jacketed for a working steam pressure of 50 lb./sq.in., but higher and lower pressures can be arranged for as desired. The domed cover is electrically interlocked and so arranged as to ensure that the main drive motor is cut out when the lid is raised. The type of cover shown is arranged with means for fume extraction. The mixer can be adapted to suit many needs. For example, the blades and saddle of the machine here depicted are serrated for shredding purposes.

[Photo: Edgar Allen & Co. Ltd.

A new design of 'British Rema' contra-flow mixer-sifter. Features include totally enclosed construction, main bearings mounted quite externally to the mixing chamber, rapid end-to-end plus radial movement of the powder particles being mixed, and consequent intimate association of the mixed materials. The standard mixing chamber has been enlarged to enable sifting mechanism to be housed directly above the mixing chamber. Spiral brushes operating within circular screening areas enable effective action on materials liable to clot or form agglomerations, while the presence of any oversize extraneous matter is dealt with at the same time. Such foreign bodies travel along the length of the screening area to be discharged automatically through an inclined chute at the end of the screening chamber. The machine finds many applications where agglomerated powders have to be dealt with, because the sifting device breaks down any lumps to grain size and all material passes through the screening area into the mixing chamber. In the condition of a batch of powder composed of separate particles as distinct from lumps or clots, the material is in its most receptive condition for inter-mixing with other constituents forming a complete mix.

The powerful geared drive and sturdy paddle are claimed to make this 'H' mixer very suitable for dealing with difficult or sticky materials. All parts coming into contact with the powder are made from stainless steel. The machine consists of a rigid cast-iron cabinet carrying the main spindle sleeve, on the front of which is mounted the overhung stainless-steel container. The drive to the paddle is from a motor mounted at the end of the machine, through V-belts, on to the totally enclosed worm and wheel, the wheel shaft then passing through the spindle sleeve and connecting with the stainless steel. The mixer, which is fully equipped with safety devices, has a capacity of approximately 100 lb. powder and employs a 2-h.p. motor.

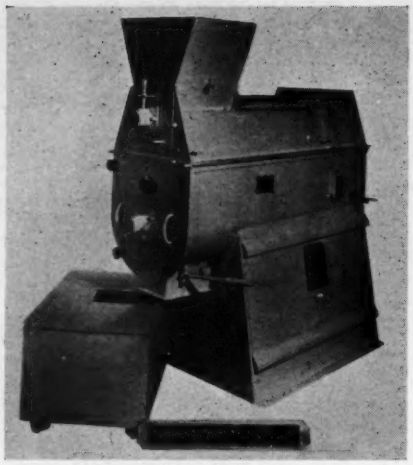
[Photo: Manesty Machines Ltd.

interfacial tension of the components, have not yet been investigated; nor has attention been given to the relation between discharge velocities of impellers and particle-size control in the suspension of solids. With regard to the mechanical design of mixing equipment, the theoretical equations for critical speeds of rotating shafts do not cover all the cases met with in practice, and experimental data are needed in this field.

An important factor in determining the value of any experimental work done on agitation and mixing, as in other branches of chemical engineering, is the scale of operation. There are still too many papers published describing work done in the laboratory with vessels only a few inches in diameter. It should be emphasised that the results obtained in such experiments, though interesting in themselves, are valueless for the purpose of scaling-up to the dimensions of industrial plant. Probably the minimum size of pilot-scale apparatus that will yield data which can be utilised in the design of full-scale plant is a 3- or 4-in. diameter impeller in a 10-gal. batch of material. At the same time, if baffles, coils, sparger pipes or other fittings are likely to be necessary in commercial operation, these should be simulated in the small-scale investigation.

[*Photo: Fordath Engineering Co. Ltd.*

Interior of mixer designed for the intensive mixing of foundry silica sands with core binders, where percentages of stiff compounds as low as 1% must be completely dispersed through the body of the sand, leaving each individual sand grain coated with its film of binder. The mixing blades rotate in the horizontal plane within the cylindrical mixing chamber. These blades are so shaped that the sand is conveyed from the centre of the pan, rubbed thoroughly against the rubbing plates disposed around the pan wall, forced up the inclined ribs on these rubbing plates and then tumbled back to the centre. After 2 to 3 minutes of this action, it is claimed, the entire batch is ready for discharge as a perfectly homogeneous mix, well aerated. When the discharge door is opened, the batch is quickly thrust out through the guarded chute and the mixer left ready to receive the next charge. Actual mixing time varies between 2 and 3 mins. Output per hour can be reckoned as at least six times the batch capacity. This mixer is also used in the welding electrode industry for both 'blending' and 'wet-mixing' of the fluxes for coating electrodes. It is also suitable for mixing refractory and ceramic compositions; for asbestos powder in fireboard and roofing manufacture; and for blending dry chemical powders, whether they be 300 mesh or coarse materials. Modification of blade shape and discharge chute can be arranged to suit particular requirements and special dust covers can be fitted where necessary.



[*Photo: W. Gardner & Sons (Gloucester) Ltd.*

This 'L' type sifter-mixer has totally enclosed built-in motor and gears. The brush, sieve and agitator can all be readily removed without disturbing the drives, leaving the whole of the interior of the machine clear for easy and thorough cleaning. The self-contained rigid construction of the machine requires no realignment and is installed by simply setting it down on a level floor, to which it is then secured. Direct connection to an appropriate electricity supply is all that is then necessary to run the unit. The sifter-mixer can be supplied for use on almost any kind of product, with parts coming in contact with the material in steel, stainless steel, Monel, brass or galvanised, plated or metal-sprayed steel.

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'I.C.E.' October

Articles include :

Heat Transfer by F. P. Stainthorp, B.Sc.Tech., A.M.C.T.

Graphical Representation of Extraction Processes by A. V. Brancker, Ph.D.

Handling Acetylene under Pressure in Chemical Reactions by S. A. Miller, Ph.D.

Rosin amine as anti-corrosive

The use of inhibited acids, especially hydrochloric acid, in applications such as metal cleaning and oil well acidising has increased considerably in recent years due to the development of effective corrosion inhibitors. Organic nitrogen compounds, particularly amines, have long been known to be effective as HCl inhibitors for steel presumably because of their ability to adsorb on the metal surface, thus forming a protective layer.

The development of an amine derivative of rosin which led to an evaluation of this product as an HCl inhibitor is described by E. A. Bried and H. M. Winn in *Corrosion*, 1951, 7 (6), pp. 180-185. Good results were obtained, but the relatively low solubility of rosin amine in hydrochloric acid imposed a concentration limitation. It was found that condensation of the amine with ethylene oxide formed oxyethylated amines which possessed good solubility in HCl and good corrosion inhibition. Even more important were the discoveries that the oxyethylated amines would act as solubilising agents for up to 15% of their weight of free amine, and that addition of free amine to the oxyethylated amines improved their inhibitive properties.

Ethylene oxide content

The optimum ethylene oxide content was determined by evaluating a series of condensates, containing from 1 to 31 moles of ethylene oxide per mole of rosin amine. The 5-mole condensate was found to be optimum from the standpoint of both inhibition efficiency and acid solubility. The addition of various amounts of free amine to the condensates improved their efficiencies and resulted in very good protection at exceedingly low concentrations. For example, the 5-mole condensate containing 15% free amine gave penetration values of 0.130 and 0.159 in./yr. at concentrations of 0.20 and 0.05%, as compared to about 17 in./yr. for the controls. Test conditions involved mild steel in 15% HCl at 165°F. for 4 hr.

The 5-mole condensate containing 15% free amine was further evaluated at 0.20% concentration by varying both the acid concentration and contact time. Weight losses of mild steel in both inhibited and control acids were determined at 10 time intervals from 8 to 240 min. in 5, 10 and 15% HCl. Curves of corrosion rates plotted as a function of time showed that in the uninhibited acids the rate increased rapidly for about 40 min., then increased slowly for the duration of the tests. In inhibited acids curves of corrosion as a function of time indicate a maximum rate at the shortest time intervals, and that the rate decreases logarithmically as a function of time. This is believed to be due to increased adsorption of the inhibitor during the course of the test.

Mixing and Agitation in Liquid Media

INSTITUTION OF CHEMICAL ENGINEERS' CONFERENCE

The design of mixing vessels is in many cases still based on empirical relationships and practical experience but in recent years much research on mixing theory has been carried out. In July a Conference on Mixing and Agitation in Liquid Media was held in London by The Institution of Chemical Engineers. Six papers were presented by authors from university and industrial research departments dealing with theoretical and practical aspects of mixing operations, experimental investigations and applications in specific industries. Below are summaries of four of the papers.

Developments in the theory of mixing

ALTHOUGH the choice of agitating equipment and the design of agitators is still largely dominated by custom and tradition, some steps towards a more rational treatment of the operation may be taken by examining the physical and chemical mechanism by which the desired change takes place and by investigations directed towards improvements in the means of imparting to the system the energy required to effect the changes. A critical review of recent developments in the theory and practice of agitating and mixing was given by Prof. D. M. Newitt, Mr. G. C. Shipp and Dr. C. R. Black, Imperial College of Science and Technology, London University, who described investigations into different mixing systems.

Systems which lend themselves to the investigation of mixing characteristics are (1) dissolution processes and heterogeneous reactions in general, (2) the dispersion and/or suspension of one phase in another, (3) the dispersion of electrolytes and (4) processes involving heat transfer.

The flow pattern produced in a multiphase system by any specific type of stirring equipment depends in the main upon a property known as consistency or apparent viscosity. Other important properties in connection with the mixing of solid-liquid systems are the wettability of the solid, particle-size distribution and the relative densities of the two phases. These factors all have to be taken into consideration in the design of a system.

In most agitating problems involving multi-phase systems, the initial dispersal of the phases demands a different flow pattern from that required subsequently to maintain the resultant mixture in dynamic equilibrium, and agitation may therefore be regarded as a two-stage operation demanding a greater expenditure of energy in the first than in the second stage.

The appropriate flow pattern fulfilling all the basic requirements for two-stage operation could in principle be obtained by the reciprocating action of a perforated piston immersed in the fluid, the mechanical arrangements being such that in one direction the whole of the apertures would be open while in the other only a proportion of them would be open. There are, however, mechanical difficulties in applying the principle to large-scale operation and most commercial agitators employ rotary mechanisms, the stirring element or rotor consisting of a paddle, propeller or turbine. The design of the conventional equipment is in fact based mainly upon the requirement for initial dispersal of the phases.

The tendency for a rotary propeller stirrer placed axially in a cylindrical vessel is to create a swirling motion or vortex and as the speed increases and centrifugal action comes into play, a column of air is drawn into the liquid and dispersed randomly at the propeller. In systems consisting of two immiscible liquids of different densities this pattern is not favourable to mixing, since the centrifugal action tends to separate the components. Other forms of propeller have other disadvantages and in general all the requirements for a suitable mixing flow pattern can only be realised by a rotor stirrer operating in a baffled cylindrical container, although the number of baffles required may be large and the power requirements of such an arrangement may be greatly in excess of the minimum required to maintain a state of dynamic equilibrium in the system.

There are a number of alternative methods of producing an optimum pattern of general turbulence combined with a vertical component of velocity which do not appear hitherto to have been applied to mixing operations. One method consists in making use of the stable motion of a fluid contained in the annular space between rotating co-axial cylinders. The authors have constructed several experimental mixers based on this principle.

The effect of baffles on power consumption was found to vary with the viscosity. The position, size and shape of the baffles was also very important and various points were investigated. The authors generally concluded that there is still room for considerable economies in agitating operations and that a more detailed study of flow patterns in relation to the desired result might lead to a more scientific design of agitating equipment.

Practical aspects of liquid mixing

Much research has been carried out on the study of mixing operations in recent years, but the diversity of problems encountered is so great that it is still in most cases impossible to design satisfactory equipment from theoretical considerations alone. Despite difficulties it is possible, however, to calculate power requirements for liquid-mixing problems with sufficient accuracy for cost estimating in a large number of cases making use of the research work of the past 20 years. Mr. Brian N. Reavell, Kestner Evaporator & Engineering Co. Ltd., discussed the practical aspects of liquid mixing and agitation dealing with the design of mixing equipment, types of rotors, mixing vessels, typical flow patterns, methods of drive, methods of mounting and special purpose mixers.

The study of flow patterns in mixing equipment proves a great help in predicting performance. The patterns can be studied for various types of rotor when working in glass vessels both with and without baffles of different shapes. Examination of the results obtained in such experiments indicates that for orthodox types of rotors used there is a definite flow pattern under optimum conditions of power consumption and mixing rate. If these flow patterns can be reproduced in full-size equipment, optimum power consumption and mixing rate will be obtained.

It is helpful to divide liquid mixing problems into three broad classes: (1) liquids with or without solids which remain free-flowing when mixing is complete, (2) liquids with or without solids which are viscous but still pourable when mixing is complete and (3) liquids with solids which form stiff pastes when mixing is complete. The theoretical approach to the design of mixing equipment becomes more difficult as the viscosity of the liquid increases, and in class 3 problems there appears to be at present no method for designing equipment than by purely empirical means.

There are many different types of rotors used for the mixing of the three categories of materials listed, but the variations are more in detail of design than in basic principle. In general, rotors of the vortex (centrifugal pump impeller) types or of the turbine wheel helical or boat impeller types are used for class 1 materials. These rotors are small in diameter compared with the size of the vessel and run at relatively high speeds, say from 500 to 1,500 r.p.m. Rotors of the helical propeller, vortex impeller, flat blade and anchor blade paddle types are used for class 2 materials but run at 10 to 500 r.p.m., according to the diameter of the vessel.

Very viscous liquids and stiff pastes as class 3 are best handled in trough mixers with two or more rotors running on separate shafts with Z-shaped blades scraping the sides of the trough. Alternatively, cylindrical vessels may be used and two or more rotors provided on separate shafts driven by 'sun and planet' gears. There are, however, many variations in the design of mixing apparatus used to handle these very viscous materials.

The shape of the vessel has a pronounced effect on the rate of mixing and the power needed to achieve a satisfactory flow pattern. The principal difficulty in obtaining satisfactory mixing in rectangular tanks is to ensure that there is sufficient flow of liquid and turbulence along the corners, which is a serious objection when solids are present in the mix. It may be that an existing vessel has to be adapted for mixing purposes, but it is always preferable to design the vessel to accommodate the type of mixing equipment best suited to handle the materials involved.

Many mixers must be designed to meet special requirements; for example, compressed air is used to maintain turbulence in certain process vessels by the use of perforated sparge pipes. Some processes require very gentle movement in the mixing vessel and in recent years the hand-operated paddles used in the storage of milk have been replaced by a simple paddle blade oscillating in a pendulum motion in the storage tank.

The major part of mixing equipment is designed for batch equipment, but there is a growing tendency for continuous working in process plants which has necessitated the design of equipment to carry out this unit operation continuously. One example where continuous operation would be an advantage is in the neutralisation of spent acid effluents from steelplate works and other industries where relatively large volumes of liquid have to be handled and batch working would involve bulky and costly equipment.

Internal circulation of droplets in liquid-liquid mixing

In liquid-liquid mixing, the dispersed phase may be in the form of droplets falling through the continuous phase. It has been shown that where diffusion is taking place circulation occurs inside the droplet in the form of a vortex and that this circulation occurs only when the Reynolds number exceeds a fairly well-defined value. At lower Reynolds numbers circulation does not occur, and the diffusion process appears to be as postulated in the two-film concept of Lewis and Whitman. The Reynolds number used in these correlations is the local external parameter

$$\frac{DV\rho}{\mu}$$

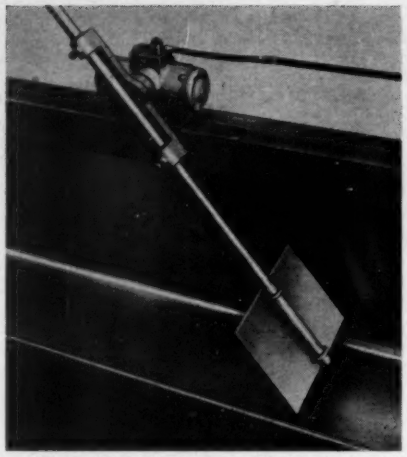
where the physical properties ρ and μ are those of the continuous phase.

Prof. F. H. Garner and Mr. A. H. P. Skelland, Birmingham University, showed that the transitional value of this group at which internal circulation occurs is also in part influenced by the viscosity of the droplet and the interfacial tension at its surface.

For droplets containing 40% butyl alcohol falling in water, internal circulation only occurred when the local Reynolds number of the droplets was over 70. Internal circulation was readily seen by dissolving cobalt chloride into the butyl alcohol mixture; as water diffused into the droplet the colour changed from blue to pink, enabling the character of the diffusion to be observed. Approximately 2% of water was necessary for this colour change. The rate of diffusion was investigated as a function of the Reynolds number, and it was found that the time taken for the colour change was much longer below the Reynolds number of 70, at which circulation commences. Above this Reynolds number, although the droplets were increasing in size, the time for the colour change was progressively reduced with increase in Reynolds number. Thus it would appear advisable to ensure that the Reynolds number of the droplets was above this minimum value in order that internal circulation could be obtained.

It was also shown in this paper that as the viscosity of the disperse phase increases, increasing Reynolds numbers are required to obtain internal circulation. The transition Reynolds number at which internal circulation occurs is proportional to the logarithm of the absolute viscosity. The lower the interfacial tension between the dispersed and continuous phases the lower is the Reynolds number required to give internal circulation. The mechanism of circulation within droplets and in the surrounding medium during the process of formation was also discussed.

The authors concluded that the surface viscosity of the fluid in the droplet is probably a major factor in determining whether internal circulation takes place inside the droplet.



[Photo: Kestner Evaporator and Engineering Co. Ltd.

The air-operated reciprocating paddle stirrer for milk referred to by Mr. Reavell. It sets up an agitation similar to a hand-operated paddle, sufficient to maintain complete homogeneity, but not strong enough to cause undesirable churning effects. The unit can be powered by electric motor or belt drive, but an air-operated model which was recently developed is more portable and considerably cheaper. The paddle normally runs at 10 to 15 strokes/min., but the screw-down air valve enables the speed to be adjusted to anything between 3 and 50 strokes/min. The unit is particularly light, and can be moved easily from one vessel to another. The length of the shaft can readily be adjusted, and a second paddle can be attached if desired. For an air-operated model working in a vat 5-ft. deep, the minimum air pressure required for normal agitation is 20 lb./sq.in., but the air motor is capable of working at pressures up to 100 lb./sq.in. A volume of 2½ cu.ft./min. is sufficient to operate the stirrer. These reciprocating paddle stirrers are now being used by fruit squash manufacturers who desire to keep fruit pulp in suspension without macerating it, and they have also been adopted in many industries where materials to be mixed are not widely different in specific gravity and where violent agitation would be both detrimental to the product and wasteful of power.

Jet mixing of fluids

Certain hydraulic criteria govern the mixing action of jets and can be applied to all fluids obeying the normal hydraulic laws. During the war Mr. H. Fossett, the Associated Ethyl Co. Ltd., initiated some work which resulted in a fairly widespread adoption of the principle of jet mixing in the petroleum field. The original work was based on a concept which was evaluated by means of model tests carried out at the National Physical Laboratory. These model tests established certain hydraulic criteria, which were subsequently confirmed at full scale in a large number of applications and over a fairly wide range of hydraulic conditions.

A concept for producing mixing in tanks by the induced action of two free jets has been formulated and a submerged and freely emerging jet diffuses in the form of a cone, entraining the surrounding fluid as a function of a transverse pressure gradient inside the cone. The author, however, considered that, by disposing the jets in a certain manner, a definite and regular flow pattern in three dimensions would be set up, and thus by setting the whole contents of a tank in motion, the intrinsic mixing of a freely dispersing jet would be considerably enhanced. It was felt that the jets meeting at the far side of a diameter would be deflected upwards and also backwards, being drawn down again into the low-pressure area in the vicinity of the jets. It was hoped, therefore, that a regular but turbulent flow pattern would be induced in the whole contents of the tank. As part of the original concept it was hoped by these means to avoid any degree of pure rotational swirl, since the author had formed an opinion based on practical experience, that rotational swirl led to inefficient mixing.

The problem which resulted in a decision

to carry out the model tests concerned the necessity of installing a tetraethyl lead mixing system in some large underground petrol tanks, which were effectively buried and, being originally intended solely for storage purposes, were fitted with two closely disposed simple pipe connections which were situated at the end of a small approach tunnel. The installation of a propeller mixer was considered, but the manufacturers, who were apparently concerned with the shallow depth of the tank relative to its diameter (20 ft. deep × 118 ft. diameter), advised a minimum of three such propeller mixers, set slightly tangentially at equal spacing around the circumference. Such a solution would not have been possible without involving extensive civil engineering work. It was possible, however, to consider a pair of divergent jets set inside the tank at the end of the inlet pipe.

The results of the model tests using this system were satisfactory and the data derived therefrom has been to a large extent confirmed in full-scale operations. All the work was conducted in tanks of various shapes ranging from a few feet diameter up to 140 ft. and there is apparently no ground for believing that application at even greater dimensional scales will not be achieved. The range of products mixed has been from the mixing of tetraethyl lead with petrol to the mixing of the various hydrocarbon components of finished petrol, lubricating and fuel oils. In this wide range no Reynolds number effect has been observed. Considerable success has been attained in mixing viscous additives with lubricating oils, which operation had presented considerable difficulties when employing the quite usual but empirical practice of air blowing. The principle has also been employed in the blending of bitumens in tanks 30 ft. diam. × 30 ft. high at temperatures of about 150°C. and a kinematic viscosity of about 160 cS.

A suggestion has been made that the simplicity of jet mixing could be applied in a case where it is desired to achieve a high degree of uniformity of temperature in a large tank.

A weed-spraying machine has been fitted with a nozzle for recirculating a portion of the pump delivery back into the storage tank, and this resulted in a very homogeneous mixture even when using a lead arsenate spray. An obvious development of this application is in the field of water treatment plants.

Some work has also been undertaken on a 120-ft. diameter tank to maintain wax in suspension in fuel oil, the deposition of wax to the bottom of such tanks being a problem. This application so far has not been resolved to complete satisfaction, but some early test work is promising.

The extension of the principle to chlorination of a large fresh-water bathing beach about 1,200 ft. × 150 ft. in area has also been suggested.

Mechanical Composting Processes

IN recent years, in many places in the United States, the increasing density of population has altered the basic economics of refuse disposal. Land areas suitable for fills are becoming increasingly scarce and must be located at greater distances from the community. Incineration has become more expensive because of the increased importance of protecting the atmosphere from pollution. At the same time the public has become increasingly aware of reclamation needs. These changing factors have reopened the question as to whether composting should be seriously considered by American communities as a feasible method for disposing of organic refuse.

Through the process of composting, practically all types of organic material can be altered to produce humus. The most important methods thus far developed are batch processes. Continuous or mechanised methods have been developed only recently, including the Frazer process in the U.S.A. All processes produce a humus which has to be dried, from about 30 to 15% moisture, before it can be conveniently used.

The Indore process is essentially a large-scale application of the traditional barnyard process. Alternate layers of garbage and straw and leaves are piled up, on the open ground or in a trench, to a height of 5 ft. If available, night soil or sewage sludge is distributed throughout and shortens the fermentation period to the minimum of about 15 days. During this period the materials are turned twice, manually. The liquors draining from the pile may be collected and recirculated through the mass.

This process, widely used in India and China, could be adapted for use by American communities by employing mechanical equipment. Disadvantages would be lack of protection from adverse weather and probable difficulties with odour and pest nuisances.

The Beccari process encloses the materials in a cuboidal cell, usually of 20 cu. yd. capacity. Vents equipped with valves are incorporated so that air can be excluded at first and admitted later. The first stage of the process is anaerobic, during which the temperature rises to about 150°F., and the volume shrinks considerably. The vents are then opened, changing the nature of the reactions and allowing the mass to dry out partially.

The Verdier process is an improvement on the Beccari process. The principal modification is recirculation of the drainage liquor, which reduces the retention period from 35 to 22 days.

The Dano process has been adapted to refuse containing large amounts of paper. It comprises two rotary drums operating in series. In the first unit, called the silo, the rotation aerates the refuse and breaks up the larger particles. The second unit, called the egsetor, is furnished with stationary grinding bars and screens, and provides further aeration and grinding down to final size. The total retention period is only a half day. The process is a conditioning which prepares the material so that it can be stored by the consumer without developing a nuisance. Final composting takes place during storage.

The Frazer process is also highly mechanised. Aeration is employed in that air is forced upwards through the waste materials moving down the tank. The retention period is from five to seven days. A single fabricated steel digester tank has 3,000 cu. ft. capacity and can receive 50 tons of refuse per loading.

The Earp-Thomas process also employs grinding, agitation and aeration. In addition the raw materials are inoculated with a special culture of bacteria.

The composting processes described produce little if any gas usable for fuel. It is possible to stabilise organic refuse through entirely aerobic processes, in the same way that sewage sludge solids are disposed of in a treatment plant digester. This method produces gaseous fuel in addition to the humus of aerobic digestion. The disadvantages of anaerobic digestion are a lower efficiency in the microbiological reactions, resulting in longer retention periods and production of malodorous gases.

In the U.S. more and more communities are disposing of garbage by grinding and discharge into sewers. The ground garbage is largely recovered in the sewage sludge, and undergoes digestion with it. Disposal of organic refuse together with the sewage sludge has the distinct advantage of making efficient use of existing sewer and sewage treatment facilities. Use of the sewers for transporting the ground garbage may decrease or even eliminate separate collection in some areas. Sewage treatment plants can be given the capacity to care for the extra load. Increased production of fuel gas and of humus fertiliser will help offset the additional costs to the sewerage system.

The history of composting progress indicates that the most economical process for use in the United States may prove to be a mechanised one in which the digesting material moves continuously throughout the period of digestion. These methods probably will be found to be considerably less expensive than the conventional non-continuous methods.

Municipal composting organic refuse may be advantageously employed by communities where the composting plant can be located adjacent to the sewage treatment works. Composting may also prove advantageous for unsewered communities, where septic tank and cesspool pumpings can be disposed of together with garbage and other organic refuse.

(Max L. Panzer and Harvey F. Ludwig: *Civil Engineering*, February 1951.)

Alkali Inspectors' Report on the Chemical Industries

THE high standards of layout, design and process control of modern chemical works are especially mentioned in the new report (No. 87) of the Alkali Inspectors.* Existing chemical works, they state, have been well maintained and, in many cases, substantially extended. Several large new works are nearing completion and other projects are in hand or contemplated. The tendency has been to install automatic and elaborately instrumented plant equipped with all possible labour-saving devices. Better planning of process buildings, good roadways and the setting out of lawns and flower beds have not only produced more attractive working conditions but their provision has also resulted in more careful operation and greater cleanliness with a consequent improvement in the amenities of the surrounding districts.

The report reflects the great activity and high rate of output of the chemical industry today, commenting that production generally has been to the limit of plant and labour available. In 1950 there were 977 works registered under the Alkali Act and these operated no fewer than 1,775 separate processes. The Chief Inspector and his deputy and the six District Inspectors in England and Wales made more than 3,500 visits during the year, while the Chief Inspector for Scotland made 420 visits.

Like its predecessors, the present report gives a revealing insight into the many technical problems of the chemical and processing industries. Here are some of the comments made by the Chief Inspector for England and Wales.

REGISTERED WORKS

Alkali works

The weight of salt decomposed and the average efficiency of condensation are shown in Table 1. The individual efficiencies from which the weighted average has been calculated are based on the NaCl content of the salt used. In a few cases, the exact NaCl content is not known and a purity of 95% has then been assumed. Where muriate of potash has been decomposed, a purity of 95% has also been assumed, but due allowance has been made for the associated NaCl. The average of escape tests made by the District Inspectors during the year was 0.107 gr. of HCl per cu. ft.

Eight instances have been recorded when the concentration of hydrogen chloride in the waste gases discharged to atmosphere has exceeded the statutory limit (0.2 gr. of HCl per cu. ft.). Two of these related to escapes from condensation systems and in both cases satisfactory conditions were quickly restored. Two further infractions related to excessive low level escapes of hydrogen chloride. Improvement here has been secured by the rebuilding of a defective scrubber and modifications to the acid circulating system, but the intention is to replace the plant by one of mechanical design.

The remaining four cases were connected with excessive concentrations of hydrogen chloride in the waste fire gases from mechanical muffle furnaces. At both works involved the escapes from the scrubber towers of the condensation systems were satisfactory and the trouble arose by reason of defective joints in the hearth through which hydrogen chloride or partly decomposed salt leaked into the fire flues.

TABLE 1. SALT DECOMPOSED (TONS)

	1950	1949	1948
In saltcake process	72,983	66,785	67,768
In wet copper extraction process	—	—	—
Total	72,983	66,785	67,768
Average efficiency % as explained on this page	96.4	95.8	95.1

TABLE 2. SULPHURIC ACID (TONS, CALCULATED TO 100% STRENGTH)
(Excluding Government plants except those producing for trade purposes)

	1950	1949	1948
Production	1,570,000	1,419,000	1,318,000
Proportion of plant in use %	92.7	93.7	93.1
Proportion made %			
In chamber plant	34.3	39.9	42.7
In contact plant	65.7	60.1	57.3
Raw materials used			
Pyrites	126,000	142,000	146,500
Sulphur and H_2S	318,000	265,000	228,000
Spent oxide	181,000	180,000	183,000
Zinc ores	176,000	156,000	149,000
Anhydrite	185,000	179,000	181,300

Sulphuric acid works

Production of sulphuric acid (Table 2) was 151,000 tons in excess of that in 1949 and the proportion of the whole made in chamber plants has fallen yet again, being now only 34.3%.

The average of tests made by the District Inspectors shows a total acidity of 1.6 gr., calculated as SO_3, per cu. ft. of the undiluted escaping waste gases.

Seven instances have been recorded where the escapes have exceeded the statutory limit of 4 gr. as SO_3 per cu. ft.

Contact processes

A serious position has arisen owing to substantial reduction in supplies of brimstone that will be forthcoming in 1951. Practically the whole of the imported brimstone has in recent years been derived from the U.S.A. and the cut now imposed will place sulphuric acid manufacturers in a most difficult position, particularly those whose plants are specifically designed for the use of this form of sulphur. Whereas chamber plants can be adapted to the use of pyrites, spent oxide, etc., the conversion necessary to adapt hot gas contact plants similarly would be a major undertaking. This difficulty has arisen at a particularly unfortunate time when the demand for sulphuric acid is greater than it has ever previously been and when a curtailment of supplies will have widespread repercussions throughout British industry. It is clearly necessary that the most economical use should be made of the available sulphuric acid and that very careful consideration should be given to any possibility of its recovery from wastes. There may well be cases where such recovery, although not attractive in the past, may yet be desirable in the present circumstances.

The figures in Table 2 show that 1,032,000 tons of sulphuric acid were produced in contact plants during 1950, that is an increase of 179,000 tons over the previous year's production. The average of all official tests on escapes to atmosphere from these plants was 2.78 gr., as SO_3, per cu. ft., that is a slight reduction from the previous year's average, which was 2.82 gr. This is a satisfactory figure in view of the overloading which many plants have carried, but which obviously still leaves room for substantial improvement.

Muriatic acid works

The class of works includes not only the manufacture of synthetic hydrochloric acid but a great variety of processes where hydrogen chloride is one of the products of reaction. In the case of some organic processes the hydrogen chloride may be

*'87th Annual Report on Alkali, etc., Works. Proceedings during 1950,' H.M.S.O., 1951, pp. 56, 1s. 9d.

associated with appreciable amounts of sulphur dioxide or with small amounts of chlorine.

The tail gas scrubbers at one works provided very efficient elimination of hydrogen chloride and chlorine until the mild steel shell of the alkali scrubber collapsed by reason of corrosion. It is being replaced by an earthenware scrubber and, in the meantime, the plant is being operated with the water scrubbers only in use. There is a slight slip of chlorine which must be tolerated until the alkali scrubber is again functioning.

A newly registered process relates to the production of an alkyl sulphate by treatment of the corresponding alcohol with chlorsulphonic acid. The plant is of sound design save for the waste gas scrubber, which is barely adequate to reduce the acidity below the statutory limit. An improved scrubber is being installed.

An infraction occurred at a works where ores are roasted with salt as the first stage of a metallurgical process and waste gases are scrubbed with water before discharge to the chimney. The hydrogen chloride content of the stack gases is usually well within the statutory requirement, although the total acidity which varies with the sulphur content of the ores (usually 1.5 to 2%) occasionally is much higher than desirable. The infraction related to failure in the use of the best practicable means to prevent low-level escapes caused by a leaking inlet connection and collapsed packing of the tower. Conditions were speedily righted.

A benzene chlorination plant found at work last year with no means for dealing with the evolved hydrogen chloride is now in good order with an acid recovery system followed by a caustic scrubber to remove any residual chlorine.

Conditions at a phosphoric acid purification plant which received adverse comment last year have been entirely satisfactory. At the sister works the absorption system was found to be inadequate to cope with the increased throughput and remedial measures are in hand.

Escapes from the so-called light factice process for the production of rubber-like substances consist of hydrogen chloride contaminated with small amounts of sulphur chloride, and can be extremely unpleasant. Caustic scrubbing recently installed at one factory and contemplated at another should largely provide a cure, although some slight slip of sulphur chloride is perhaps inevitable.

Reference has been made in two previous reports to conditions at a works operating a relatively high temperature process involving organic compounds which cause operational difficulties in that gas lines tend to choke owing to condensation of solids volatilised from the main reaction. It is believed that the chemical engineering design aspect has been satisfactorily settled and a rubber-lined special type of absorber is on order. In the meantime, temporary units which corrode rather rapidly are in use.

Whilst investigating a complaint against an unregistered works it was found that a small plant where certain organic materials are heated in presence of zinc chloride constituted a registrable process. A wash tower has been provided to deal with the main escape of hydrogen chloride, but escapes via the muffle are still such that the works cannot yet be accepted as fit for registration.

An infraction occurred at a factory operating a chlorsulphonation process due to the use of insufficient water on the scrubbing towers and to a disorganisation in timing so that four batches were being processed at one time in place of the usual two. The towers have now been overhauled and increased water supply arranged.

At a large works where organic chlorinations are carried out on a large scale an excellent system for absorbing hydrogen chloride and excess chlorine was installed, but troubles were soon encountered due to failure of the materials of construction. Pending a permanent solution an emergency system has been applied which is quite efficient in that escapes of acid gases and chlorine are almost nil; it is, however, uneconomic, as there is no recovery of acid as such.

Serious local emission of hydrogen chloride occurred at a works using a Friedel-Crafts reaction wherein an aryl chloride is reacted with excess benzene in presence of aluminium chloride. Owing to an inaccurate laboratory report, it was assumed that reaction was complete and the mixture harmless from the point of view of gas emission. Further processing revealed this was far from being the case as there was a sudden evolution of hydrogen chloride with which the system was unable to cope. The unit is alongside a public road and a passer-by and the driver of a bus were affected, fortunately not seriously. As a result, supervision has been tightened up, the waste gas system is being altered and the general technique modified.

UNREGISTERED PROCESSES

Coke Ovens

Work is proceeding steadily on the National Coal Board's new battery of coke ovens at Nantgarw which, it is hoped, will be in operation by the end of 1951. The renewal of existing ovens and extensions thereto on this site has also continued. Similarly the Steel Co. of Wales' new ovens at Margam are nearing completion and should be in use by mid 1951.

At its East Greenwich gasworks, the South Eastern Gas Board has built a battery of ovens which was put into service at the end of September. The ascension pipes from the ovens are fitted with steam ejectors and deliver into two collecting mains. The ovens, with clay luted doors, are loaded through four ports by a travelling charging machine with means for automatically controlling the amount of coal to be delivered from each hopper.

Three additional batteries are being built by the National Coal Board. The first two will be provided with Beimann mains and the last with a double collecting main. Also under erection are batteries at two privately owned works, while at another some of the existing ovens are to be rebuilt. In each case, although a recommendation was made for the provision of either a double collecting main or a compensating main in order to reduce smoke emission during charging, the suggestion was rejected on account of the cost involved. However, plans for another privately sponsored battery which is being built embody a double collecting main and all the desiderata for smokeless operation.

Dust and fumes from metal processes

Continued attention has been given to the problem of zinc oxide emission resulting from the large-scale recovery of copper from scrap brass at a metal works and the local authority agrees that a slight improvement has been effected. It was recommended that *Fibreglass* should replace hessian in the filtering sleeves of the baghouse. This has now been done, with the result that the baghouse can be run at a much higher temperature, thus reducing the volume of diluent air formerly admitted for cooling purposes and allowing a larger proportion of furnace gases to be treated. On account of the shortage of zinc oxide at the present time, it has been decided to increase the baghouse capacity by lengthening the filtering sleeves, and it is anticipated that by this means it will be possible to clean all the furnace gases before they are discharged to atmosphere.

A complaint against a works recovering metal from scrap related to smoke and fumes evolved during the process. Investigation indicated that the most likely causes of offence were intermittent black smoke from the combustion of fuel oil, zinc oxide fume from the melting of scrap brass and smell arising from the incineration of insulated copper wire. Plans were already under way for the building of a new works on an adjoining site and, as this would be provided with a 200-ft. chimney, it was arranged that those processes most likely to produce offensive fumes should be transferred thereto, when the high-level discharge would secure more effective dispersal of the gases. It was also agreed that a modern incinerator would be installed to deal with insulated wire. The transference of these operations will afford some relief, but the proximity of dwelling-houses to the factory and the nature of the work carried out therein makes occasional complaint almost inevitable.

Lime and magnesia works, etc.

At a lime works against which complaint is outstanding, a new mechanical drying

plant equipped with cyclonic dust arrestors has been commissioned and appears to be effective. Other minor improvements have also been made, but the works as a whole is not well kept and a higher standard of 'good housekeeping' is desirable.

There is little progress to report in connection with the carbide process at a factory mentioned in the previous report. Plans for an enclosed or covered furnace are, however, being prepared and installation will presumably follow if the cost does not turn out to be prohibitive. The much reduced volume of gas from a closed furnace could be comparatively easily dealt with and, moreover, the gases would probably be of sufficient calorific value to be profitably used.

Good progress has been made at a magnesia factory, the fog-like discharge from which has caused local discontent for a long time past. A new kiln has been built and two sets of wash towers and electrical precipitators are being provided to deal with the fumes from the new kiln and the largest of the three existing kilns. It is anticipated that two kilns will be able to produce the required output and that it will no longer be necessary to use the two small kilns.

There has long been a complaint also of dust from lithopone manufacture at a certain works. The problem is a difficult one and the only solution seems to lie in the extension of a continuous type of plant such as was installed in 1949. The latter has been subject to many teething troubles and, although these are being gradually overcome, the stage has not yet been reached when duplication can be confidently recommended. Nevertheless, dust losses on the new plant are but half of what they are on the old one. Cyclone dust arrestors have proved inadequate and will probably need to be supplemented by bag filters.

A sticky dust emission from spray drying of a detergent has caused complaint in the neighbourhood of the factory concerned, but water spraying, together with a better arrangement of cyclones, has proved effective.

Emission of fluorine compounds

The research department associated with two steel works has further investigated the possibility of substituting some other fluxing material for fluorspar in the steel melting process. No suitable alternative has been found, but there have been indications that the amount might be reduced, especially when the modern method of lancing the steel furnaces with oxygen is practised. This line is being followed up. Meanwhile, at another steel works it is proposed as an experiment to carry the waste gases from one furnace—at present discharged at a height of 85 ft.—to an unused 160-ft. chimney. There is difficulty in effecting this alteration owing to the existing structural layout, but details are being worked out. Laboratory work at another has indicated that a substantial proportion of the fluorine in the waste gases could be removed by cooling to below dew point. The total volume of waste gas is, however, very great and cooling would present a major problem, besides introducing the likelihood of serious corrosion. A pilot plant is to be constructed in order to establish working data and to ascertain whether such a method would be practicable on a large scale. Cattle are no longer kept on the farm where cases of fluorosis were reported in 1949.

Fumes from galvanising and metal pickling

Galvanising operations at a metal works led to complaint owing to the escape to atmosphere of ammonium chloride and zinc chloride fumes. These fumes are hygroscopic and persistent and, moreover, so finely divided that arrestment is almost impossible. A ventilation system was therefore installed which ensured that the fumes should be discharged well above the roofs of houses in the vicinity.

Continued attention has been given to another factory where acid fumes from the pickling baths had worried local residents. After much delay the company installed a scrubber, which although crude and unlikely to withstand corrosion for long, did nevertheless effect a satisfactory reduction of the fumes discharged to atmosphere. The complainants have expressed satisfaction, but the Alkali Inspector has recommended the company to provide a draughting system and a properly designed scrubber of a more permanent character.

Phosphorus works

All the mud furnaces at one factory have been altered to allow for a continuous feed of mud. This has resulted in a number of furnace openings (*i.e.* periods of potential phosphorus pentoxide escape) being reduced to less than one-sixth of that previously necessary. Work has also continued on the electrical precipitation of impurities from the phosphorus vapours and it is hoped to have a completely redesigned unit in operation early in 1951. A second phosphoric acid unit has been successfully commissioned and 14 of the 16 old units, with their low-level phosphorus pentoxide escapes, have been closed. The two remaining units are worked well within capacity and are provided with efficient tail gas scrubbers.

Similar alterations to those mentioned above have been made to the phosphorus mud furnaces at another phosphorus works.

A proposal to establish a phosphorus factory aroused much opposition and the local authorities concerned sought the views of the Alkali Department. It was ascertained that the factory would produce phosphorus only, *i.e.* no phosphorus derivatives would be made and the authorities were advised that by application of available 'best practicable means' it should be possible to operate such a factory without undue disturbance of amenities. The application for consent was eventually called in by the Ministry of Town and Country Planning, who finally gave approval to the proposal.

Fatty acids

Serious complaint was made against a factory operating a process for the oxidation of one of the alcohols to produce the corresponding fatty acid. This operation is unavoidably accompanied by an extremely unpleasant and persistent odour characteristic of acid. The Alkali Inspector concluded, however, that it could be reduced by enclosing reaction vessels wherever possible, the use of caustic soda scrubbing and a strict policy of 'good housekeeping.' These measures have been put into operation.

Producer gas plant

A producer gas plant was the cause of complaints of offensive odour and the tarnishing of metal articles. At this works, producer gas is cooled and cleaned by bringing it into direct contact with water. The water, having absorbed some hydrogen sulphide from the gas is itself cooled before recycling, by passing it over a frame cooler, and in this process the hydrogen sulphide is disengaged and discharged to atmosphere. The addition of soda to the water had been practised with the idea of fixing the hydrogen sulphide but had been stopped because it was feared that the production and emission of ammonia might result. It was recommended that the addition of soda should be resumed, the optimum concentration to be ascertained by practical trial. These recommendations were accepted and the experiments are now in hand.

Hair treatment process

The processes at a factory treating hogs' hair have been modified by repairs to the steeping tanks, raising these above ground so that any leakage would be more readily detected and fixing hoods over them so that offensive vapours could be draughted away and discharged to the boiler chimney. Owing to the risk of fire, however, the works manager was averse to allowing the draughting fan to be used at night when the works was closed although the steeping process continued. This difficulty is now being surmounted. The treatment of liquid effluent by hypochlorite has proved effective.

Paper works

At a paper works chlorination of the chimney gases failed to result in the hoped for deodorisation. Attention has therefore been concentrated on combustion conditions within the kiln whence the objectionable odour is emitted, and some amelioration has followed the provision of forced draught. Further trials are in hand.

The British Association Meeting

SUMMARIES OF CHEMICAL SECTION ADDRESSES

This year's annual meeting of the British Association for the Advancement of Science—the 113th—was held in Edinburgh from August 8 to 15 under the presidency of the Duke of Edinburgh. Distinguished academic and industrial chemists contributed papers to the chemistry section of the meeting. Four of these papers are summarised below.

Chemistry at the Mid-Century

By Sir Cyril Hinshelwood, F.R.S.

IN his presidential address to the chemistry section, Sir Cyril Hinshelwood reviewed the advance of chemistry to date and invited society to face the challenge recent chemical discoveries place before us.

He saw the great chemical discoveries of the past century as the evolution of views about the basic substratum of things, the perfection of the arts of synthetic chemistry, and the growth of knowledge about the laws of energy and of the intimate mechanism of chemical changes. Now, after a long and eventful approach, the chemist stood face to face with the problem of life itself.

Early ideas about atoms and the manner of their union were naive. They had gradually become more sophisticated and more abstract, and now chemical valency had to be interpreted in terms of electrons with properties quite unlike anything known to ordinary observation. Behind this there seemed to lie some deep mystery relating the possibility of detection with the very existence of the entities postulated in physical theories, and in a glass darkly one seemed to see here some connection with the mind-matter problem itself. The present situation was unsatisfying to many, but it should not be concluded too readily that the limit of knowledge, or taking long views, even of the power of human understanding, was yet reached.

Much of chemistry was of a more workaday character and unconcerned with these deep questions. Structural chemistry, now in the early stages of becoming a mathematical science, had not only revealed the underlying atomic patterns of things, but enabled the chemist to weave designs of his own choosing. The deeper understanding of mechanisms had not only led to understanding but to control.

It had often been questioned whether the powers of chemistry were used to good or evil ends. To this an emphatic answer might be given: chemistry had in fact conferred vastly more benefit than harm on mankind; the men of science were in no way responsible for the abuse of their discoveries by others. The desire to inhibit scientific discovery rested, moreover, upon an utter lack of faith in human destiny.

The detailed understanding of what happened in chemical changes had revealed a picture surpassing in wonder that conceived by the poetic imagination of Lucretius. It was now being extended to the events occurring in living cells. The selective influencing of cell processes opened the door to the great field of chemotherapy, though generations might pass before all the promise of this was fulfilled.

As the cell disclosed its secrets there would emerge the possibility of deep-seated intervention of man into the fashioning of his own biological future, and those of little faith might raise more vigorous cries than ever.

Concluding, Sir Cyril said that scientists at the mid-century were faced with difficult problems both scientific and human. If in face of hopes and fears they sought a policy, they would do well simply to follow the advice of Candide, ' Il faut cultiver son jardin.' If they did this unconcernedly, their own garden would not fail to go on producing its fruits.

A Hundred Years of Organic Chemistry

By Prof. A. R. Todd, F.R.S.

The century 1851-1951 had been an eventful one for organic chemistry. Indeed it had seen the science grow from a rather confusing and empirical body of facts into one of the most systematic and fascinating of the sciences and one on whose progress, moreover, many of the amenities of our modern civilisation depended.

The year 1851 could almost be regarded as a turning point in organic chemistry, for major developments destined to shape the whole course of the science were at hand. Early in the 19th century Berzelius had defined organic chemistry as the chemistry of substances produced by living matter in contradistinction to the inorganic substances of mineral origin. There were certain striking differences between the two types and in Berzelius' mind, as in those of his contemporaries, these were associated with the vital force concept. Wohler's laboratory synthesis of urea in 1828 was generally believed to have sounded the death knell of the vital force theory, but in fact it survived for long after that and it still reared its head in the famous textbook of Gmelin (1854). In the years that followed Wohler's discovery, however, Liebig and others had shown that the organic compounds all contained carbon and that carbon compounds with similar properties could be obtained from non-living sources, *e.g.* coal tar. So it gradually came to be recognised that organic chemistry was in effect synonymous with the chemistry of the carbon compounds and attention was directed to the understanding of carbon chemistry, since it was clear that until such an understanding was obtained little progress was to be expected in studying the chemistry of living matter. By 1851 the efforts of many chemists had produced a substantial body of factual knowledge, but despite type theories and radical theories there was no really satisfactory theory of valency which could correlate the facts and establish the inter-relationships of organic compounds. In 1852 E. Frankland made the first clear statement of the idea of valency or fixed combining power of an element. This was a great step forward and it was followed in 1858 by the work of Kekule and Couper, who independently put forward a theory of molecular structure based on the quadrivalency of carbon and the capacity of carbon atoms for joining together in chains; they showed how molecular constitution could be represented diagrammatically in graphic formulae and could predict the existence of isomers. That more isomers did in fact exist than were allowed for by this theory was, however, clear from the earlier work of Pasteur who had shown that two optically active tartaric acids exist. This was clarified in 1870 by van't Hoff and Le Bel, who added to the Kekule-Couper ideas the concept of the tetrahedral carbon atom and thereby introduced the idea of space or stereoisomerism. With this the whole subject was placed on a firm basis and on these theories virtually the whole of the modern science arose. Only in comparatively recent years had alterations in basic ideas of molecular structure come from physics through knowledge of the electronic structures of atoms, but even these new ideas had not altered the essential applicability of theory laid down between 1850 and 1870.

Armed with this understanding of structure the study of the carbon compounds flourished exceedingly and by the early 20th century a vast number of such compounds were known and methods of synthesis and analysis had been developed in great variety. During this period, too, began the rise of the great organic chemical industry, producing dyestuffs (starting from the initial aniline dye of Perkin), explosives, etc. This rise of an industry

notable for its closeness to the advancing front of a science has continued until today it produced not only dyes and explosives, but plastics, detergents, photographic materials, drugs, fabrics and a multitude of other things which we accepted without question as part of everyday life; there were, indeed, few of the material comforts of life which did not owe something to organic chemical industry.

The 20th century had seen, however, a remarkable development in our knowledge of chemistry in relation to living matter. During the latter half of the 19th century organic chemists paid scant attention to this side of their subject and even biochemists were relatively few. It was only in this century that great strides in biochemistry had been made.

From the organic chemist's viewpoint this was inevitable. The materials found in living matter were too complex for him to study with success until he had mastered the groundwork and developed methods for studying carbon compounds in general. This mastery came from the work of the late 19th century and as the 20th began we could see the beginnings of a move towards the goal of the early organic chemists in the work of Fischer, Willstätter and others on the proteins, purines, sugars, natural colouring matters and enzymes. This movement had grown continuously, receiving enormous impetus through the development of micro-techniques, enabling work to be done with tiny quantities of material, and in the past 25 years it had given most of the spectacular achievements of organic chemistry in the structural elucidation and synthesis of hormones, vitamins, alkaloids, natural colouring matters, etc., and indirectly of the synthetic drugs. Parallel with it had come the developments in the understanding of the finer details of molecular structure and reactivity associated with the names of Lapworth, Robinson, Pauling and Ingold. The welding together of the results and ideas emerging from these two fields of endeavour promised still more striking triumphs for organic chemistry in a future which should be as fascinating as its past.

Petroleum Chemicals

By Dr. F. Roffey
(Controller of Research and Development, Distillers Co. Ltd.)

The petroleum chemical industry could be defined as that section of the chemical industry which derived its raw materials from petroleum or natural gas and, in very general terms, had its main influence in the large-scale production of aliphatic rather than aromatic products. In this respect, it was in a sense complementary to the much older coal-tar industry, although many highly important developments were based on the use of intermediates derived from both.

Like the oil industry from which it stemmed, the petroleum chemical industry had made remarkable progress since the middle twenties and, bearing in mind the predominant place of the United States both as a producer of crude oil and natural gas and as a user of various refined oil products, it was not surprising that most of the major developments in the derived chemicals had taken place in that country, although far from insignificant progress was being made elsewhere, particularly in Great Britain since the war.

A brief survey of the history of petroleum chemicals was given and production statistics of some selected major products of the industry were quoted to demonstrate its phenomenal growth and overall position in the industrial economy of those countries in which it had become established.

An attempt was made to show the lines of development by means of charts indicating the two main steps between raw material (oil) and end product (chemicals). The first step was essentially the responsibility of the oil industry, namely the break-down of any given feed stock into its component hydrocarbons or closely related groups of hydrocarbons, this operation being carried out in the refinery by a combination of cracking and distillation; while the second consisted of the synthesis of the required chemical end products from the individual components of the refinery operations, this being the task of the petroleum chemical side.

The main raw materials used on the purely synthetic side of the industry were the olefinic constituents of cracked oil, namely ethylene, propylene, the butylenes and butadienes from which were derived, either directly or by condensation with selected aromatics such as benzene and toluene, the majority of the larger tonnage end products such as synthetic ethanol, glycol, isopropanol, which in turn was converted to acetone, higher alcohols and ketones and some highly important bases for the polymer and detergent industries such as styrene, phenol and the condensate of polymerised propylenes with either benzene or toluene.

More recent developments based on direct oxidation of natural gas to give a wide range of oxygenated compounds were also summarised, together with the modified Fischer-Tropsch process based on natural gas which aimed at producing both gasoline and oxygenated chemicals on a very large scale. Finally, the production of acetylene and hydrocyanic acid by petrochemical processes was reviewed.

Synthetic Polymers

By Dr. J. C. Swallow
(I.C.I. Ltd.)

Synthetic polymers formed the basis of three industries of ever-growing importance, namely synthetic plastics, fibres and rubbers, and their growth of manufacture and of uses had been one of the most spectacular developments in the chemical industry in the last decade. These industries had a common scientific background, but different technologies in application, and were all based on polymers which were macro-molecules made by the process of polycondensation and polymerisation. Those materials which had been selected for large-scale production represented a selection from a large number of synthetic polymers produced in the last 20 years.

To obtain a general picture of synthetic polymers one could divide them into three overlapping zones, namely the rubber-like, the amorphous or glasslike, and the crystalline- and fibre-forming zone, from which it was possible to appreciate how their properties were related to their structural features. It was also possible to see what chemical changes were necessary to bring a polymer from one zone to another, and a number of examples were quoted, such as the chemical modification of nylon, the chlorination of polythene, etc. The crystalline polymers formed the basis of a number of new synthetic fibres such as nylon and *Terylene*, which were made by the new technique of melt spinning. Within such a classification of synthetic polymers one could in certain cases synthesise deliberately a polymer with the properties required for a specific application. However, there were other methods of modifying structure without altering the skeletal chain, and in the field of fibres this was done by blending different kinds of synthetic fibres or natural fibres with synthetic ones.

Also, by varying the degree of orientation of a long-chain molecule the physical properties of fibres could be altered to give high tenacity and low elongation, or lower tenacity and greater elongation more akin to the wool fibre. The morphology of solid polymers was therefore of increasing importance in the technical application of polymers.

With the great range of possibilities available in polymeric chemistry, what were the limiting factors which prevented the production of these new materials in sufficient quantity for all our needs? The lag of seven to ten years between the discovery in the laboratory and the successful production on an industrial scale which existed before the war had still to be faced, as were also the further economic difficulties since the war. The orderly introduction of new materials into modern economy represented one of the more difficult tasks facing chemical industry and the industries which used these products to obtain new technical effects.

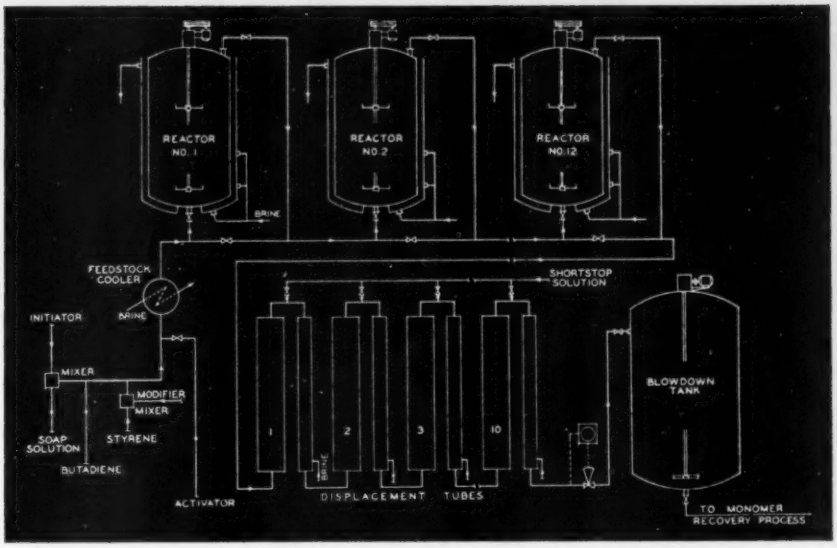
Raw materials for the production of synthetic polymers were, on the one hand, coal from which we derived benzene, the basic raw material for the thermosetting group of products, nylon and polystyrene. For the other plastics such as polythene and the synthetic rubbers we required the olefines which were most conveniently produced from the cracking of oil, a new and growing development in the aliphatic industry.

Continuous Cold Rubber Process

IN 1948 plans were initiated to convert the first half of the U.S. Government-owned 60,000-ton-p.a. synthetic rubber plant at Port Neches, Texas, to cold rubber production. Cold rubber has superior properties to 'hot' rubber and differs from the regular GR-S hot rubber by reason of the lower temperature of polymerisation of 41°F. instead of 122°F. The stripping, coagulation and drying procedures remain relatively unchanged. To accomplish the polymerisation reaction at the lower temperature while still maintaining the same reaction rates without the sacrifice of production capacity necessitates the use of a considerably different polymerisation recipe, one that is greatly activated by more potent catalysts or initiators and additional activators.

At Port Neches, the Goodrich plant was polymerising hot rubber by the continuous method, having been successfully converted from the batch process in 1945. The development of a continuous cold rubber process at this plant is described by M. W. Larson, B. F. Goodrich Chemical Co., in *Chemical Engineering Progress*, 1951, 47 (5), pp. 270-274. Although at the time of conversion a continuous cold rubber process was impractical, the advantages of continuous polymerisation were such that it was decided to design the process for initial production on a batch basis with provisions for rapid conversion to continuous operation.

The diagram shows the continuous process for cold rubber production which was eventually adopted. In this process the hydrocarbon-water emulsion flows continuously through twelve 3,750-gal. reactors in series, at the rate such that the hold-up time in the system represents the reaction time of the process. The raw materials are added at constant flow rates to the charge header, the rate of each ingredient being controlled by a flow-controller recorder or proportioning pump in the same manner as in continuous production of hot rubber. Soap solution, initiator, butadiene, styrene, modifier and activator are added to the charge header in that order. The emulsion is then cooled continuously in the feedstock cooler with refrigerated brine. After leaving the charge cooler the emulsion enters the bottom of the first reactor, overflows from the top of the first reactor and on to the second reactor, etc. After leaving the twelfth reactor the latex passes through ten 'displacement tubes' in series, latex entering the bottom of the tube and overflowing from the top. The tubes are 18 in. in diameter and 30 ft. high and have a volume equivalent to about one-tenth of one of the large reactors. The primary purpose of these tubes is to provide small volume vessels which are representative of small increments of the reaction time. Shortstop may be added at the top of any one of the tubes, thus providing a simple method of



Flowsheet of continuous process for cold rubber production.

varying the reaction time by small increments when desired without changing flow rates. A back-pressure regulator is provided to assure against butadiene vaporisation and to maintain constant flow conditions in the polymerisation system. Since the entire system is hydraulically filled, the raw material feed pumps provide the necessary pressure to transfer the latex to the blowdown tanks without the use of the blowdown pump necessary for batch blowdown.

Refrigeration equipment

The selection of refrigeration equipment for the process was influenced by local conditions. The existence of open non-pressure-type jackets on the reactors prevented the use of direct refrigeration with refrigerant in the jacket. This factor plus the availability of 15-lb./sq.in. exhaust steam at a low cost gave preference to the 'package'-type centrifugal machine and 15-lb./sq.in. steam turbine drive. Economical steam-condensing vacuum was determined to be 26 in. Hg. Surface-type steam condensers were used to permit recovery of steam condensate.

The obvious advantages of calcium chloride brine from the standpoint of heat transfer, safety and economy is somewhat offset by its increased corrosive properties; however, after inspection of numerous brine systems, it was decided that proper use of corrosion inhibitors would minimise the disadvantage and calcium chloride was chosen as the coolant.

Water de-aeration

A constant menace to a successful cold process is an excessively long reaction time and one of the accepted causes for retardation is dissolved oxygen. At the Port Neches plant water is de-aerated to < 0.1 p.p.m. oxygen at the water-treatment plant in order to minimise corrosion. It became important to minimise any subsequent aeration while dissolving soap, activator, etc. Existing solution tank agitators caused adsorption of as much as 10 p.p.m. of oxygen. By modifying agitation to eliminate vortex formation this was reduced to 2 p.p.m.

Advantages of continuous process

The chief advantage of the continuous process is increased capacity. Other important advantages are the improved uniformity of process control and product quality, reduced operating labour and reduced surges on utilities. A further advantage which has not yet been fully exploited is the possible use of waste heat exchange on the feedstock stream and finished latex. More than 65,000,000 lb. of cold rubber has been produced continuously since the first unit went into operation at Port Neches.

Contributions and Correspondence

THE EDITOR *welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to* THE EDITOR, INTERNATIONAL CHEMICAL ENGINEERING, 17 Stratford Place, London, W.1.

Letters for publication on any of the subjects covered by this Journal are also invited.

Nuclear Power Problems for Chemical Engineers

Some of the chemical engineering and related problems which must be solved before a power generating atomic pile can be operated as a normal industrial process, are outlined by J. P. Baxter, Professor of Chemical Engineering, New South Wales University of Technology, Sydney, in the first number of 'Reviews of Pure and Applied Chemistry,' a new journal published by the Royal Australian Chemical Institute. Although the problems in this field are many and formidable, it is felt they are the kind which modern engineering can solve, given the time, money and staff that are necessary. Below is a summary of several factors which arise in attempting to design nuclear power plant.

A DESCRIPTION of the British experimental pile, Bepo, was published in the August issue of INTERNATIONAL CHEMICAL ENGINEERING. This pile was designed for experimental investigations and the production of radioactive isotopes. Such a pile has some points in common with a pile for power production, but in other respects it will be very different. In order to get useful power from a pile it will be necessary to operate at a high temperature, and to extract heat from the pile at this temperature. This great heat can then be used in any appropriate way to yield electric power.

An increase in temperature of some hundreds of degrees will have no effect on the nuclear reaction but will have a profound effect on the materials of construction of the pile. It will greatly increase the problems of oxidation and corrosion, and the strength of many materials, for example aluminium alloys, will be affected adversely. Owing to the requirements of neutron economy most of the normal high-temperature materials used in boiler construction cannot be considered, as their capture cross-sections are too high. All these problems have to be solved before designing a successful pile.

Supply of uranium

Having produced the basic design, the solution to a number of chemical engineering problems must be found before the power generating pile can be operated as a normal industrial process. Firstly, it is necessary to have a supply of uranium and to be able to prepare from this the required uranium metal and other compounds. It is also desirable to have supplies of thorium and other chemical substances and intermediates. Among the less plentiful elements uranium and thorium are not particularly scarce and it is estimated that they occur in about the same quantities as tin, cobalt, lead or zinc. Economically workable deposits of uranium are nevertheless not so plentiful as those of the metals of similar abundance and the recovery of uranium from the main workable and low-grade sources presents some interesting problems to the chemical engineer. Thus it can be seen that if the development of atomic energy proceeds to the point where it makes a major contribution to the world's power supplies, then the availability of uranium will become a problem.

Furthermore, it is a peculiarity of the atomic processes that they require materials, and particularly uranium, at a very high level of purity. The original specifications called for uranium metal and various salts of this element with impurities in concentrations which were from 10 to 1,000 times lower than the limits detectable by the best methods of analysis then available. These specifications required the determination of many elements in the table, for some of which no analytical methods were known, although analytical research has now overcome this difficulty. A major contribution to the production of very pure uranium was the development in America of the ether-extraction process which enables practically all the impurities to be removed and a product to be obtained of a remarkably high standard of purity for a material produced on an industrial scale.

Uranium is a highly reactive element and when hot combines rapidly with oxygen and nitrogen. It also reduces or attacks practically all oxide refractories. It is exceedingly poisonous, and fumes or dust containing it must on no account be inhaled or swallowed. It will be seen, therefore, that the operations of preparing, melting and fabricating the metal present many difficulties when carried out on an industrial scale.

Uranium hexafluoride, required for the operation of processes for the separation of uranium isotopes, rapidly attacks practically all types of hydrocarbons and raises special difficulties in the design of pumps, valves, gaskets, etc., for use in plant handling this substance. Ordinary lubricants and greases cannot be used and a special range of fluorocarbon oils has been developed which is inert to uranium hexafluoride.

Moderator materials

Atomic energy production requires supplies of moderator material. If graphite is chosen, it will be necessary to provide large tonnages in a very pure form. Although commercial synthetic graphite is remarkably pure, in general it is not pure enough for pile construction. The methods adopted to produce a satisfactory product have not been disclosed, but it is obvious that selection of raw materials and possibly some preliminary treatment before graphitisation might be used.

If deuterium is chosen as moderator, then a supply of heavy water on a substantial scale becomes necessary. In this case there is no shortage of raw material, but a really satisfactory and cheap process of concentration is still required.

If beryllium was adopted as a large-scale moderator, the position would be equally unsatisfactory, as world supplies of beryl are thought to be limited.

Operational problems

Foremost among the problems which arise during operation of a power pile is the treatment of the uranium metal which is withdrawn from the pile in order to keep down the concentration of fission products. When the uranium is withdrawn from the pile it is exceedingly radioactive and heavy shielding will be required to protect operators. If the material is then stored its activity will then fall off, but unfortunately it is impracticable to wait for decay to become almost complete and it is therefore necessary to process the uranium while it is still radioactive and to put up with all the inconvenience.

Recovery of plutonium

The next stage is the purification of the uranium from fission products, coupled with the recovery of plutonium, if that is desired. From the point of view of the chemical engineer, the main problem in this recovery process is the interference with normal methods of control and maintenance, due to the need for complete radioactive shielding at all stages. This means that all controls must operate remotely, and that the taking of samples for analysis and similar operations must be kept to a minimum, as they become exceedingly slow and cumbersome when remotely operated. More serious than this is the fact that normal maintenance becomes practically impossible and plant must be so designed that it does not require to be repaired or maintained. This means that such plant items which normally need attention from time to time cannot be used at all and other new methods of plant construction must be adopted. The ability to inspect and certify materials and

methods of construction becomes of prime importance, as a failure of any of these items in service will stop the plant and it may become necessary to abandon it.

Chain reaction

Another interesting problem which the plant designer must bear in mind when constructing apparatus for the concentration of fissile material, is the fact that as impurities are removed and the concentration of fissile substance increases, the point may be reached at which a chain reaction may commence. This would be a major disaster and its avoidance calls for very accurate accountancy in the operation of these plants, as the loss of, say, 1% per cycle or batch might, if the lost material were accumulating in one place, have very serious consequences.

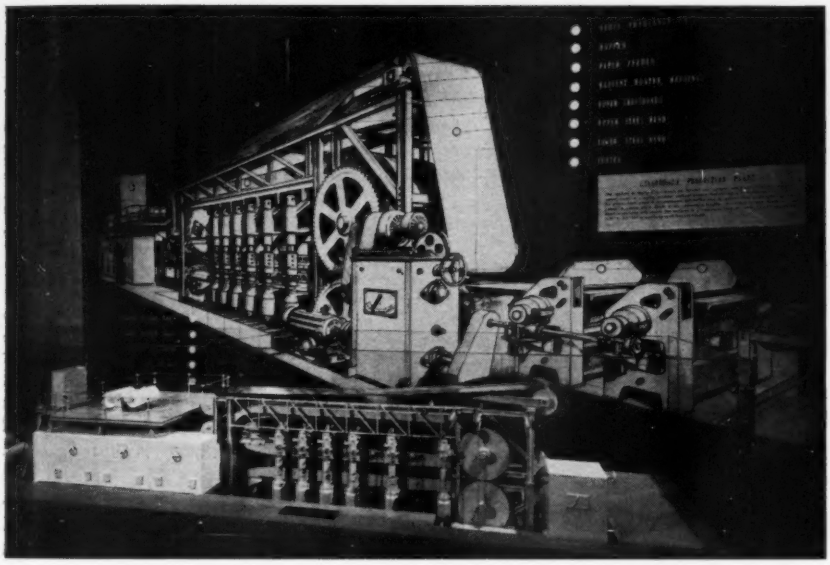
Disposal of fission products*

A final problem which affects all plants for the removal of the fission products from uranium is what to do with them after they have been separated. Storage of the fission products seems to be the only safe answer, but as it can be imagined, this presents many problems for the engineer to solve.

All these difficulties, together with the need for complete protection of the operators against radioactivity, add to the design problems of the engineer and increase the complexity of the plant. They also add enormously to the operating difficulties, particularly with regard to the handling of unskilled or semi-skilled labour.

*An excellent symposium on radioactive wastes and their disposal appears in the July 1951 issue of *Industrial & Engineering Chemistry*.

Continuous manufacture of boards from wood waste



Working model and scale drawing of *Celloboard* production plant.

Although the production of constructional boards from wood waste is not new, it is claimed that manufacture on an economic scale is now possible for the first time by the *Celloboard* continuous process developed by the Vere Engineering Co. Ltd. The essential principle of production is the mass preparation of wood waste to ensure the required particle size and humidity. A resinous composition, chemically balanced to give rapid bonding of the material is then added under accurately controlled conditions. Plant has been devised to facilitate this preparatory process whatever the condition of available waste, although in some circumstances existing grinding plant can be adapted. A continuous carpet of prepared material is automatically fed through a high-frequency heating plant and then through a heat and pressure zone which cures the resins and forms the finished board which leaves the press in a 4-ft. wide continuous sheet in thicknesses from $\frac{3}{16}$ to $\frac{3}{4}$ in. and at speeds up to 20 ft./min. It is claimed that one unit alone can produce 16,000 tons of *Celloboard* p.a.

This process is claimed to permit precise control of quality, density and thickness previously precluded by the necessity for producing boards batchwise in limited sizes. The board is said to be light, fire-resistant, vermin-free and sterile. To meet local conditions of vermin or fungus attack, materials such as benzene hexachloride can be added to the raw material. The boards can be faced with paper or fabrics during actual manufacture, or can be laminated in secondary operations with wood veneers, plastic laminates or light metal. By 1953 it is expected that plants will have been established in the U.S.A., Canada, Australia, S. Africa, India, S. America and European countries.

Analysis of cast iron, aluminium and lead

THE analytical determination of specific substances in metals formed the general subject of three papers recently presented at a London meeting of the Society of Public Analysts.

Magnesium in cast iron

A method was described by W. Westwood and R. Presser for the chemical determination of magnesium in cast iron by dissolution of the metal in hydrochloric acid, extraction of most of the iron with *iso*-propyl ether, removal of manganese and some of the remaining elements by electrolysis with a sodium amalgam cathode, complex ion formation with citric acid of any remaining interfering elements and double precipitation of magnesium as phosphate. Zirconium interfered with the method as described.

Sodium in aluminium

The determination of sodium in aluminium and its alloys by vacuum distillation was described by W. McCamley, T. E. L. Scott and R. Smart. A quantitative separation of sodium from aluminium and many alloying constituents has been obtained by distilling the metal *in vacuo* at 900°C. The sodium in the distillate can be rapidly and accurately determined by the zinc uranyl acetate method.

The method has been successfully applied to all commercial grades of aluminium and to many aluminium alloys. In the upper ranges of sodium content (*i.e.* above 0.005%) there was good agreement with existing methods and the precision was considerably higher. However, the range of the new method extends far below that of any previous method, and is limited mainly by the quantity of sample it is convenient to use. Under the conditions described, sodium contents of 0.0001 to 0.001% were determined with a standard error of $\pm$0.00014%.

Lead oxide in lead

A method was described by R. M. Black for the estimation of lead and lead oxide in lead dross by means of the reaction between lead monoxide and an ammonium salt to give ammonia and the corresponding lead salt. The ammonia was removed from the solution by steam distillation, absorbed in an excess of boric acid and the ammonium borate so formed titrated with standard acid in the usual manner. The method gave reasonable accuracy with quantities of lead oxide as small as 10 mg., but further development is required before it becomes applicable to small oxide inclusions in lead sheathing alloys.

Distillation equations

In the equations in the article, 'A Mechanical Analogue for Separation Problems' (page 325, July 1951), in order to comply with standard distillation nomenclature, for φ read y and $\varkappa$ read x.

Plans for a French Synthetic Rubber Industry

FRENCH rubber requirements in 1951 are expected to amount to 120,000 tons, comprising 107,000 tons of natural and 13,000 tons of synthetic, it is revealed in the report drawn up by the Union des Industries and the Union des Chambres Syndicales de l'Industrie du Petrole at the instance of the Minister of Industry and Commerce, on the possibility of synthetic rubber production in France. Consumption in 1949-50 totalled 99,500 tons, comprising 92,200 tons of natural and 7,300 tons of synthetic, and was accounted for as follows: tyre covers 75,000 tons, inner tubes 10,000 tons and other uses (industrial and domestic) 14,500 tons.

By 1953, requirements are expected to have risen to 135,000 tons, if account is taken of the expected general economic development and the growth of military needs. This quantity will consist of 100,000 tons of tyre covers, 13,000 to 14,000 tons of inner tubes and 20,000 tons for other purposes.

The 30,000 to 40,000 tons of GR-S (including 1,500 tons of GR-N) and the 10,000 to 12,000 tons of butyl rubber which the report says could be produced in France from 1954 onwards could thus play an important part in ensuring French rubber requirements. It would also impart some element of price stability to rubber products, though perhaps at a higher price level than might be economic if present high demand should eventually subside. The quantity of GR-S and GR-N would cover about 25% of French rubber requirements, *i.e.* the whole of the industrial rubber requirements and a small part of France's needs in tyre covers, and also perhaps a small amount of export requirements.

Butadiene

After a detailed examination of the processes which might be used, with due reference to the supplies of raw materials which would be most easily and most economically available in France by 1954, the report concludes that the butadiene required for the manufacture of GR-S could be most suitably produced by the utilisation either of petroleum refinery gases or of ethyl alcohol. Three-quarters of a ton of butadiene are required for each ton of GR-S. Thus for 40,000 tons of GR-S some 30,000 tons of butadiene would be required. The report estimates that the 43,500 tons of normal butylene required for the manufacture of this amount of butadiene would be available by the end of 1953, provided the oil refinery programme had been carried out as envisaged and the planned catalytic cracking plants were in operation by 1953. The production of the requisite quantity of butadiene from alcohol would require some 80,000 tons of 95° alcohol, or about 1,000,000 hectolitres, which could be obtained from the French alcohol industry. Production of the requisite butadiene from acetylene or liquid petroleum fractions is rejected as being too costly.

Styrene

The 10,000 tons of styrene needed to manufacture 40,000 tons of GR-S could be obtained, employing today's most widely used process, by the dehydrogenation of ethyl benzene at 630°C. in the presence of a catalyst. This quantity would require 8,700 tons of benzene and 3,200 tons of ethylene; the former should be available on the French market, though part of it might have to come from new production on the part of the chemical industry, while the ethylene could be obtained by the recovery of certain refinery gases and the manufacture of certain chemical products.

The polymerisation of the butadiene and the styrene would be obtained by a cold process entailing emulsion in water in the presence of an emulsifying agent and of catalysts.

Costs

The investment necessary for the production of 40,000 tons of GR-S would amount to some 18,000,000,000 francs, using refinery gases, and 14,500,000,000 if ethyl alcohol were used. The cost of manufacture by these two processes has been worked out as a function of the prices of the chief ingredients—unseparated butylene for the former process and alcohol for the latter. To give some idea of comparative costs, however, the compilers of the report have worked out, on the basis of prices in January of this year, the following approximate cost prices of the GR-S produced:

Using:	*Francs (per kg.)*
Unseparated butylene assumed to cost 27 francs/kg.	210
Alcohol bought at its cost price of 85 francs/litre	375
Alcohol assumed bought at the price of 50 francs/litre ..	280

These prices compare with the following quotations (per kg.) for natural rubber c.i.f. French ports:

	Francs
Average for 1949	115
January 1, 1950	145
January 1, 1951	550

The butyl rubber would be manufactured by the polymerisation of isobutylene and isoprene, of which 12,000 and 450 tons would be required respectively for the production of about 11,000 tons of butyl rubber annually. The isobutylene would be available under the refinery programme for 1953, and no difficulties are anticipated in acquiring the necessary quantity of isoprene. The polymerisation would take place at a very low temperature (—100°C.) in the presence of catalysts. It would involve important low-temperature problems and would require a high consumption of energy.

The amount of capital investment required would be in the neighbourhood of 4,500,000,000 francs, and the cost price would appear to work out at somewhere around 200 francs/kg. (including amortisation and interest). This price is of the same order as the current price of imported GR-S: 193 francs/kg. f.o.r. French ports.

All these figures of costs have been worked out from American experience, which is on a much larger scale than that envisaged in France. More accurate and detailed figures will emerge from investigations now being made.

To conclude, the compilers of the report are in no doubt that synthetic rubber could be manufactured in France by 1954 and at prices which compare favourably with the present price of natural rubber. The big doubt is clearly in the future movement of natural rubber prices.

Recent publications

Spray driers. Bulletin No. 112, issued by George Scott & Son (London) Ltd., gives illustrated details of spray drying as applied to plastics, aniline dyes, soaps, glues, tannin extracts, pharmaceuticals, etc. Scott spray driers are designed for handling from 4 to 300 gal./unit/hr. of liquid. At the Scott research station in London a spray drier of semi-industrial size is permanently available for tests and demonstrations.

Heat-resisting equipment. The remarkable heat-resisting properties of nickel and of its alloys with chromium and iron are well known. On heating in air, these alloys develop adherent oxide films with refractory properties which prevent the progressive oxidation and sealing experienced with steel and many non-ferrous materials.

These alloys not only resist progressive oxidation, but also possess good mechanical properties at high temperatures, so that failure of heat-treating equipment due to sagging, distortion, etc., is minimised, and the necessity for large, heavy structures which wastefully absorb heat is reduced. Furthermore, the range of materials now available will meet a wide variety of operating conditions. A new publication issued by Henry Wiggin and Co. Ltd. discusses the high temperature properties of *Nimonic* 75, *Inconel*, *Nimonic D*, *Mangonic* and pure wrought nickel, and by quoting actual uses it gives guidance to the most economical choice of material for a given set of conditions of temperature, loading and requisite life.

New Plant and Equipment

Heavy duty filter press

A filter press marketed by the National Pump & Engineering Works, Johannesburg, for use in gold mines, oil mills, yeast factories, chemical works, etc., comprises heavy head and tail stocks, connected by longitudinal bars which carry the plates and frames and on which they are free to slide. The frames form the filter chambers. The chambers are closed and tightened by a screw and reduction gear, which forces the plates and frames together, making a gasket joint with the filter cloth. A quick-release mechanism is provided to avoid inconvenience of turning the capstan the full distance required to open the press. A separate discharge for the filtrate is provided from each chamber, or a closed discharge can be provided if required. The filter presses are available in three sizes, 12-in. square plates, 24-in. square plates and 30-in. square plates; each size may be built up to the maximum of 10 chambers in the first case, 30 chambers in the second and 40 in the third, with approximate maximum total filtering areas of 20, 240 and 500 sq. ft. respectively. Minor amendments to suit particular individual requirements can be effected to any required size.

A laboratory model filter press is manufactured in the 12-in. square plate size. It is usually found that two chambers are sufficient for most purposes. For small manufacturing plant, more chambers may be added. It can also be supplied complete with pump and motor.

Plates and frames are available in several metals, *e.g.* aluminium alloy, acid-resisting bronze or iron, or a non-ferrous metal with an inert coating which is useful in food processing.

Low-temperature air-separation plants

A range of air-separation plants, claimed to be the first of their kind to be produced regularly in the U.K. on a commercial basis, is now being supplied by Petrocarbon Ltd. In these plants special attention is paid to air purification in order to prolong the running period before defrosting is necessary. Carbon dioxide is removed by scrubbing with caustic soda solution, and oil and water vapour are removed by adsorption on activated alumina. The particular advantage of activated alumina is that, while giving extremely high drying efficiency, it can be regenerated *in situ* and lasts almost indefinitely.

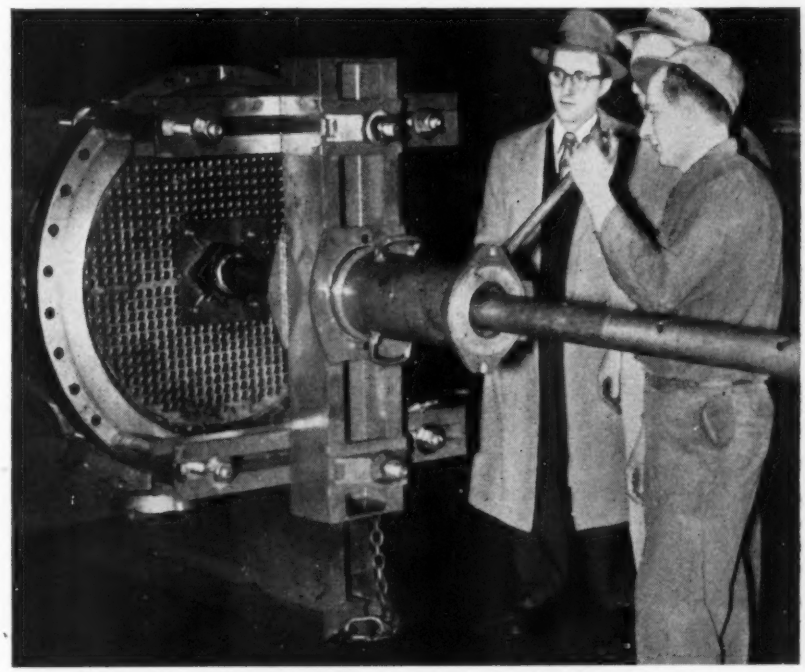
The type D medium-size oxygen or nitrogen plants are of the high-pressure double-column type. The double column, consisting of one rectification column superimposed on another, with a condenser-reboiler between, enables a high yield of either oxygen or nitrogen to be obtained, thus giving greater economy in power consumption than the simpler single-column plants, while requiring more head-room. The plant consists of an air compressor, scrubbing unit, drying unit, precooling unit, separation unit, oxygen or nitrogen compressor and cylinder charging manifold. The drying and separation units are suitably lagged and encased in stout steel lagging cases with all necessary valves and instruments mounted on their front panels, the finish being cellulose enamel with chrome fittings. The precooling unit is a commercial refrigerating unit consisting of a *Freon* compressor and water-cooled condenser with accessories. It is provided with a guard cover finish similarly to the drying and separation units, the three being designed to place *en bloc* with the precooling unit behind the other two, although other arrangements are possible.

The plant consists of works-assembled units throughout. In larger sizes, the caustic scrubbers and pumps have to be despatched separately, and individually erected on site, but the drying unit, precooling unit and separation unit are works-assembled before despatch. Type D1 has an oxygen output of 1,060 cu.ft./hr. or a nitrogen output of 4,500 cu.ft./hr., while type D2 has an oxygen output of 2,500 cu.ft./hr. or a nitrogen output of 10,000 cu.ft./hr.

H.F. evaporator for metallising

The problem of putting polished metal finishes on non-conducting materials has, until recently, been solved for only a few combinations of base substance and metal. One satisfactory method of metallising unplatable materials is to condense metal on to their surfaces from the vapour state. This technique has become standard in many plants manufacturing metal-coated plastics. In most vacuum evaporators the metal is placed within a helical or conical filament made of high-melting-point metal such as tungsten or tantalum. This method has certain disadvantages which limit its applications, but all these problems are solved if the directly-heated filament is eliminated.

A laboratory evaporator, modified to use high-frequency induction heating to melt and evaporate the metal, is described by R. G. Picard and J. E. Joy, in *Electronics*, 1951, **24** (4), pp. 126-128. The equipment uses an electronic generator which operates at 70 Mc/s with 1 KW output. In operation, a small crucible is placed within the water-cooled work coil but not touching



HEAT EXCHANGER REMOVAL

Demonstration of the removal of a heat exchanger by a new technique recently developed in the U.S.A. Bundles in shell and tube heat exchangers may now be removed by a special exchanger jack which has been designed to reduce construction costs and to enable exchangers to be supported above the ground by eliminating conventional pulling beams and their related structures. The tube bundle removing device is portable and consists of a modified commercial centre-hole hydraulic puller which can exert a pull of 12,000 lb. for a maximum distance of 16 ft., permitting the removal of dirty bundles, which can be replaced by the same equipment after cleaning.

it (to minimise thermal shock to the crucible) and the metal is place in the crucible. The surface to be metallised is positioned above the crucible, the bell jar is placed on the base plate and the pumps are started. After a vacuum of the order of 10^{-4} mm. of Hg has been obtained, the h.f. power is applied and evaporation proceeds. An extremely good vacuum is needed because of the intense h.f. fields existing in the jar. If the pressure exceeds 10^{-4} mm. Hg, these fields will ionise the residual gas in the chamber, dissipating the power in the gas instead of heating the metal.

The evaporator as constructed is claimed to have worked satisfactorily for a wide variety of metals. Its rated power of 1 KW at 70 Mc/s has proved adequate. The results obtained with it show that all of the objections due to directly-heated filaments have been overcome. Uncontaminated surfaces of any metal may now be produced.

The process has, however, some disadvantages when compared with direct-heating evaporators. The H.F. generator is more complex and more expensive, and it must be shielded to prevent radio interference. The efficiency of the heating drops as the metal evaporates and the charge gets smaller, and it is virtually impossible to evaporate a charge completely. However, for many cases where it is essential to evaporate metals, which, for one reason or another, burn out filaments rapidly, or where uncontaminated metal surfaces must be obtained, the authors recommend the h.f. evaporator.

Flame photometer for checking feed-water make-up

Tight control over the make-up of boiler feed-water is essential for large industrial plants in order to assure uniform conditions and protection from corrosive and scale elements in steam generators at all times. Although widespread use of ion exchange units has greatly simplified the engineering problems, frequent, accurate control checks are still necessary to check out-going feed-water and exchange capacities of the resin.

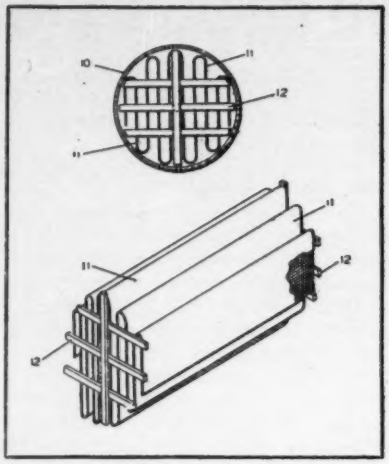
One such example from a recent steam generator installation is the Dow Chemical Co.'s Midland, Michigan, power plant, described in *Perkin-Elmer Instrument News* (1951, **2** (2), p. 3). Three 1,250-lb./sq.in. cyclone steam generators are geared to an intake of approximately 4,000 gal./min. of water. Since the water must be silica-free, Dow demineralises in a series of ion exchange units.

Every 2 hr. sodium determinations are made with a flame photometer on both the raw-water feed and the cation effluent, in order to obtain exchange capacities of the resin as well as to keep a very tight control on the water produced. Satisfactory silica removal is achieved by adding fluoride in the form of the sodium or ammonium salt in 50% excess of theoretical requirements.

On leaving the demineralising units, the water has an average specific conductivity of less than 1 micromho with less than 0.04 p.p.m. of silica, nil iron, and a *p*H of around 9.

With the flame photometer, sodium content can be accurately determined in 30 sec. down to 0.1 p.p.m. and estimated to hundredths of a part. The flame photometer also serves to locate leakage from mechanical trouble in valves, etc. Total water costs, including chemicals, wash water and cost of water processed were about $.27 per 1,000 gal. a year ago.

The use of the flame photometer for alkali control in cement manufacture was described in INTERNATIONAL CHEMICAL ENGINEERING, December 1950, p. 554.



Novel form of solid catalyst recently patented in the U.S.A. and described in our July issue, p. 338. It is claimed to improve temperature and reaction control in stationery bed catalytic units as used in hydrocarbon conversions.

18-in. glass pipeline

After more than 18 months' research and development, Quickfit & Quartz Ltd. have put into production a glass pipeline 18 in. in diameter. This is claimed to be the world's largest glass pipeline in quantity production. Made in sections, it is especially suitable for production of drugs and fine chemicals, and will substantially increase the scope of glass chemical plant in these industries.

Mr. B. H. Turpin, technical and sales director, said that the difficulty of producing a glass pipe of so large a diameter was initially in the production of the pressed pipe flange, and later in joining the very thick pressing to the main body. He added that the new 18-in. pipeline is particularly suitable for hydrochloric acid absorption towers.

New Plant and Equipment

Fill in the Enquiry Coupon on page 446 for further details of the equipment and plant described in INTERNATIONAL CHEMICAL ENGINEERING.

Vacuum-type ultracentrifuge

The analytical ultracentrifuge has been a valuable tool for determining the molecular weights of high molecular weight substances since the pioneering work of Svedberg and his associates over 30 years ago (Svedberg and Pederson, *The Ultracentrifuge*, Oxford University Press, 1940). In practice there are two general methods.

The first is known as the rate of sedimentation method and requires a centrifugal field large enough to produce an easily measurable rate of sedimentation. The second is known as the sedimentation equilibrium method and requires the centrifuging to continue long enough for the sedimentation to be balanced by back diffusion.

The first method usually requires at the most only a few hours while the second method may require several days of centrifuging. A magnetically suspended vacuum-type ultracentrifuge which has been used for both methods but is especially suitable for the latter is described by J. W. Beams, J. D. Ross, and J. F. Dillon, University of Virginia, in *Review of Scientific Instruments*, 1951, **22**, (2), pp. 77-80).

A centrifuge rotor constructed of steel and Duralumin ST-14 weighing 4.93 kgm. and having a radius of 65 mm. to centre of the standard centrifuge cell, which contains the material to be centrifuged, is suspended magnetically in a high vacuum (pressure not less than 10^{-5} mm. Hg). The rotor is driven to running speed by an air turbine below the vacuum chamber. The turbine is connected to the rotor by a small steel shaft along the axis of rotation and passing through vacuum-tight oil glands into the vacuum chamber. When the rotor reaches operating speed, the shaft is disconnected and the rotor is allowed to coast freely during the sedimentation experiment. This is possible because of the very small deceleration of the rotor (less than 0.1 rev./sec./hr.). As a result the temperature and rotor speed not only can be measured accurately, but can be maintained very nearly constant.

Largest h.f. induction heater

Equipment recently installed at the De Havilland Propellors Ltd. is claimed by the makers, Phillips Electrical Ltd., to be the most powerful valve-driven h.f. generator in Europe. This type F280 high-frequency induction heating generator has a maximum output of 150 kW (continuous) and 200 kW (intermittent) and is used for hardening metal.

The unit operates on a mains supply of 380 to 440 V, three-phase, 50 cycles, and requires a maximum power input of 280 kVA. At 150-kW output, the power factor is 0.9 and the nominal operating frequency 275 kc/s. The equipment weighs 3 tons and measures approximately $4\frac{1}{2} \times 12 \times 7$ ft. in height.

Liquid Fuels from Coal

IN view of the limited world reserves of petroleum it may be necessary before many years have passed to utilise oil shale and natural gas and, ultimately, coal as a source of liquid fuels. Owing to the unequal geographical distribution of crude oil and the disturbed international situation, the synthetic production of liquid fuels from indigenous raw materials can become economically or strategically desirable locally, irrespective of the world petroleum-oil supply position.

With these comments, Dr. C. C. Hall of the Fuel Research Station, London, opened his paper entitled 'Synthetic Liquid Fuels' before a joint meeting of the London and South-Eastern Counties Section of the Royal Institute of Chemistry and the Scientific Society of the Acton Technical College, which was held at the college recently, with Dr. C. W. Herd in the chair.

In the British Commonwealth, Dr. Hall continued, reserves of crude oil, oil shale and natural gas are very meagre and interest centres mainly on the production of oil from coal. Where there is a big demand for smokeless solid fuels, low-temperature carbonisation of coal provides a source of liquid fuels, but where liquid fuels are required as the main product, the only processes available are coal hydrogenation and the Fischer-Tropsch synthesis.

Development of hydrogenation

In the past, the conversion of coal into high-grade petrol by hydrogenation was a three- or four-stage process operated at 250 to 300 atm. pressure and at temperatures in the region of 400°C. The initial conversion of the coal to heavy oil and the conversion of this heavy oil or of crude coal tars to a vaporisable middle oil was effected in the liquid-phase, using tin catalysts, and the conversion of this middle oil to motor or aviation fuel took place in two consecutive vapour-phase stages in the presence of fixed beds of granular, tungsten disulphide catalysts. During the war the Germans increased the operation pressure to 700 atm., making it possible to use two stages, one liquid phase and one vapour phase, and to employ cheaper catalysts. Since the war, only the United States Bureau of Mines has been active in further research and development on the coal hydrogenation process. It has recommended improvements which should materially increase the thermal efficiency of the process and has carried out experimental work on a simplified form of process in which a fluidised bed of fine coal is hydrogenated at pressure as low as 70 atm.

Although coal hydrogenation was used in the past mainly to produce various grades of petrol as the sole liquid products, nevertheless it possesses considerable flexibility and can, for example, be operated to produce heavy fuel oil as the major product. Moreover, it forms a more fruitful source of aromatic hydrocarbons, phenols and bases for use in the chemical industry than does coal carbonisation.

The Fischer-Tropsch process in U.S.A.

The Fischer-Tropsch synthesis of liquid hydrocarbons from carbon monoxide and hydrogen was extensively employed in Germany during the war years, with coal as the raw material, and has recently been industrialised in America with natural gas as the raw material. The process is the subject of an extensive programme of research by the U.S. Bureau of Mines and by the Fuel Research Station of the Department of Scientific and Industrial Research. In the original German process, a granular cobalt catalyst was employed at atmospheric or at 10 atm. pressures and at 180 to 200°C., in reaction vessels of complicated construction and very low space-time yield. The products consisted of low-grade petrol, high-grade diesel oil and waxes. In modern developments, iron catalysts are used at higher temperatures and pressures, making possible the production of higher yields of higher-grade petrol and conferring an overall greater flexibility on the process. The use of the fluidised-catalyst technique and of reaction systems where the catalyst is in direct contact with liquid cooling medium has led to simplification of reactor design and has greatly increased space-time yields. In addition to liquid fuels, the process can be used to produce a wide range of aliphatic chemical products.

The modernised Fischer-Tropsch process is generally considered at the present time as more economic than hydrogenation for the production of petrol from coal. This view, however, is not shared by the U.S. Bureau of Mines and, in future where coal is to be used as the main source of liquid fuels and chemical products, it appears likely that both processes will be utilised.

Discussion

The chairman opened the discussion by asking Dr. Hall for information on the production of chemicals from coal, as opposed to fuel from coal.

In reply, Dr. Hall stated that for the production of chemicals the Fischer-Tropsch process would probably prove more economic than hydrogenation. However, it must be remembered that, for commercial success, chemicals produced from coal must be produced at a price which compared favourably with similar chemicals produced by petro-chemical processes.

Taxation and duty would also have to be taken into account. For example, petrol produced by the Fischer-Tropsch process enjoys a preference over imported petrol, but petrol imported for the production of chemicals (as opposed to use as a fuel) pays no duty.

Mr. S. J. W. Pleeth asked if consideration had been given to exploiting naturally occurring tar-sands as a source of liquid fuels.

The lecturer replied that naturally occurring tar-sands were being investigated. He also mentioned that Commonwealth sources included the Alberta oil deposits which were, as yet, far from fully developed.

In a second question, Mr. Pleeth asked for further details of the economics of the production of liquid fuels from coal in South Africa. It had been stated that the project would be economical with South African coal at 5s. per ton. What would happen if the cost of coal increased due, say, to raising the standard of living of miners in South Africa?

Replying, Dr. Hall explained that in South Africa the mines were relatively shallow with thick seams. The coal was, therefore, more easily won than in this country. It was considered that future increases in the wages of the South African miner would be offset by increased mechanisation, so that more coal would be won by higher-paid miners and the overall effect would be to keep the price of coal at much about the figure of 5s. per ton which had been mentioned.

Dr. J. H. Skellon referred to the production of margarine by the Germans from hydrocarbons, derived from the Fischer-Tropsch process, during the war years. He asked if the D.S.I.R. were following up this use of synthetic organic materials derived from coal.

Dr. Hall said that this field had been investigated, but was not considered promising. Firstly, the margarine produced in this way was medically unsatisfactory and, secondly, its production in this way was uneconomic.

Mr. D. Freeland asked if the Fischer-Tropsch process had been considered as a source of alcohol which could be used as a fuel.

Dr. Hall pointed out that alcohols could be produced by adjusting the conditions in the Fischer-Tropsch process, but alcohols so produced would be of greater value as chemical intermediates than as liquid fuel.

On a second point, Mr. Freeland asked if it was a lucky accident that had led the Germans to adopt tungsten sulphide as the catalyst in the hydrogenation of coal. It would appear that a sulphide catalyst would be less likely to be poisoned by the sulphide impurities derived from coal.

In reply, the lecturer stated that tungsten sulphide had been adopted by the Germans following a search for a sulphide-resisting catalyst.

On a third point, Mr. Freeland asked if consideration had been given to using the lush vegetation of the tropics as raw

material for the production of liquid fuel; say, alcohol by fermentation.

Dr. Hall considered this an interesting suggestion, but pointed out that very large plants would be needed and that such a process would create a tremendous effluent problem.

Another questioner asked the approximate cost of alcohol by the Fischer-Tropsch process.

Dr. Hall explained that it was not possible to give data on this point. Alcohol was not the only product from the process. Any alcohol produced would be separated and sold at current market prices, and set as a credit against the cost of producing the liquid fuel which was the main product.

Mr. A. G. D. Emerson asked whether it was possible to use the heat generated in the Fischer-Tropsch process to provide the heat and power necessary for running the auxiliary equipment of the plant without 'topping up' with energy from an external source such as a boiler plant.

In reply, Dr. Hall said that, whereas the thermal efficiency of the actual production by the Fischer-Tropsch process was only 25%, the overall efficiency, including such items as steam raising by waste-heat boilers, was approximately 55%. In Germany it had been found possible to make the plants thermally self-sufficient.

International Conferences

September 8-9. International Union of Chemistry 16th general conference, New York.

September 8-12. Association des Ingenieurs sortis des Ecoles Speciales de Gand international technical conference on 'Applied Science in the Textile Industry,' Ghent, Belgium.

September 10-13. International Union of Leather Chemical Societies second biennial congress, London.

September 11-13. General discussion on 'Heat Transfer' by the Institution of Mechanical Engineers and American Society of Mechanical Engineers, in co-operation with other professional societies.

September 11-20. Building research congress, London.

September 14-15. International Union of Chemistry general conference, in conjunction with U.S. Bureau of Standards, New York.

September 16-19. Institute of Metals autumn meeting, in conjunction with the Italian Society of Metallurgy, Venice, Italy.

October 15-19. First World Metallurgical Congress and 33rd U.S. National Metal Congress and Exposition, organised by the American Society for Metals, Detroit, Michigan.

October 26-27. Institute of Mathematical Statistics conference and meeting of the American Mathematical Society, Washington, D.C.

World News

GREAT BRITAIN

Chemical glassware factory

A new factory will be built at Stone, Staffs, by Quickfit & Quartz Ltd., manufacturers of laboratory and industrial chemical glassware and one of the Triplex group of companies. It is expected that building will commence this month. The new factory will produce chemical plant, including the world's largest glass pipeline with a diameter of 18 in. (see p. 440). New annealing furnaces and specialised equipment, at present being designed, will be features of the new building.

Sulphuric acid production

The cut in sulphur supplies is reflected in the figures for the sulphuric acid output for the second quarter recently published by the National Sulphuric Acid Association Ltd., which show a production of only 79.1% of capacity. However, stocks of sulphuric acid increased slightly from 60,036 tons of 100% H_2SO_4 on April 1 to 64,965 tons on June 30. Stocks of raw materials in tons on June 30 compared with April 1 (in brackets) were, pyrites 71,900 (63,980), spent oxide 216,745 (198,137), sulphur and H_2S 78,471 (56,483), zinc concentrates 25,327 (24,061) and anhydrite 275 (60). Total consumption of sulphuric acid for the same period amounted to 416,506 tons, which included 189 tons exported. Imported acid amounted to 15,454 tons and home production to 402,082 tons.

Changes in export control

The Board of Trade have announced alterations in their export licensing regulations. The regulations became operative on August 1.

From that date licences will be required for the export to any destination of scaffolding tubes (new and used), indium and its compounds, phthalic acid esters and p-chloronitrobenzene.

Licences will be required for the export, to any country other than the Commonwealth (excluding Hong Kong), Irish Republic and U.S.A., of boron carbide, certain carbon powder, aluminium and its alloys in additional forms, calcium metal, certain types of chemical process vessels, specified pumps and parts, chucks, expanding arbors and collets, dynamometers, certain types of furnaces and certain synthetic organic chemicals of the kinds used as flotation reagents.

In future licences will **not** be required for export of iron and steel pipes and tubes, fabricated iron and steel structures (other than prefabricated buildings and machinery parts), steel furniture, windows and frames, and for perforated sheets, expanded metal, electrical laminations, and unassembled motor vehicle bodies (for licence-free types of vehicles), guttering and rainwater and soil pipes and fittings, all of iron or steel, and including alloys containing more than 55% iron.

Exporters requiring further information should approach the Export Licensing Branch of the Board of Trade, Regis House, 43-46 King William Street, London, E.C.4. (Tel.: Avenue 3111.)

New Anglo-U.S. carbon products company

Powell Duffryn Carbon Products Ltd. of London and the Great Lakes Carbon Corporation of New York have jointly formed the British-American Carbon Corporation in the United States to manufacture and sell carbon and graphite and a wide range of carbon and graphite products used principally by the chemical, metallurgical and other processing industries.

The new company will be the sole producer in the U.S. of carbon and graphite manufactured directly from coal by the Powell Duffryn *Delanium* process and its products will include the specialities developed by Powell Duffryn Carbon Products Ltd. in this country, such as the Powell Duffryn cubic heat exchanger, *Paragrid* carbon scrubbing towers and tower packings and other products.

Mr. William J. Crawford, formerly of Great Lakes Carbon Corporation, has been elected president of the new company, whose offices will be situated initially at 18 East 48th Street, New York City, New York, U.S.A.

B.I.S. appointments

Mr. W. E. Cash, M.Sc., F.R.I.C., M.I.Chem.E., and Mr. J. H. Dunn, B.A., have been appointed to the board of directors of British Industrial Solvents Ltd. Mr. F. R. Hebley, A.C.A., has been appointed secretary of the company.

New Fisons research director

Mr. C. E. Horton, C.B.E., M.A., has been appointed director of research to Fisons Ltd. He was previously director of research to the Admiralty. His headquarters will be at Harvest House, Ipswich, with laboratories at Bramford, Suffolk, and at Loughborough, and he will develop and co-ordinate the research activities of the company throughout the whole organisation.

Change of address

Crack Pulverising Mills Ltd. have moved to Plantation House, Mincing Lane, London, E.C.3.

HOLLAND

Fatty acids by solvent separation

The chemical plants division of the Blaw-Know Co. has been awarded a contract for a complete processing plant to be built in Gouda. Placed with Blaw-Knox by Lindeteves Inc. of New York for M. V. Vereenigde Stearine Kaarsenfabrieken of Gouda, Holland, the contract calls for plant design, procuring of equipment, supervision in erection and assistance in initial operation.

The plant will employ the *Emersol* solvent separation process for producing stearic and oleic acids used in the manufacture of cosmetics, polishes, special soaps, lubricating compounds and similar products. (For details of a British *Emersol* plant, see INTERNATIONAL CHEMICAL ENGINEERING, February 1950, p. 73.)

NORWAY

Aluminium production plans approved

The Norwegian Parliament has voted in favour of an appropriation of £3,500,000 for the aluminium plant which the Government plans to build at Sunndalsora, western Norway (see INTERNATIONAL CHEMICAL ENGINEERING, March 1951, p. 135). The plant is to produce 40,000 tons of aluminium annually and the total cost is estimated at £17,500,000, while a further £5,000,000 will be required to expand the Aura hydroelectric power station. Under an agreement the E.C.A. will make available the necessary foreign currency, to be repaid over a period of ten years in the form of aluminium from the new plant.

Uranium reactor in operation

A few weeks ago the uranium reactor, built at Kjeller, near Oslo, came into operation for the first time, and produced its first radioactive isotope. Norway, Britain and France are the only countries in Western Europe possessing uranium reactors, and when the Kjeller reactor starts regular production of isotopes at the end of this year it is hoped to supply the other Scandinavian countries, Holland and Belgium with isotopes. The Norwegian reactor, claimed to be the cheapest so far built, cost under £1,000,000 including the heavy water and uranium. Attached to the reactor is a staff of about fifty, including six from Holland (see INTERNATIONAL CHEMICAL ENGINEERING, May 1951, p. 238).

FINLAND

Alcohol exported to U.S.A.

Alkoholiliike Oy., Finland, the State alcohol monopoly, carried on a substantial export trade in industrial alcohol with the U.S. in 1950. Exports amounted to between 7,000,000 and 8,000,000 gal., valued at $3,000,000. This commodity is obtained as a by-product of cellulose manufacture. It is expected that the market will continue and that this product will provide an important new source of dollar exchange.

Nitrogen factory progress

The new nitrogen factory under construction at Oulu is expected to be in operation by the latter part of 1952. It will have an annual capacity of 16,000 metric tons of nitrates and will supply about 80% of domestic requirements of nitrogenous fertilisers, all of which are now imported. The project is financed by the State, and Typpi Oy., the company building the plant, is Government-controlled.

FRANCE

Nitric acid plant for Israel

The Israeli Government has placed an order for a complete nitric acid plant with the Batignolles-Chatillon company, according to the publication *Usine Nouvelle*. The major part of the plant, which is valued at over 200,000,000 French francs, will be built at the Nantes works of Batignolles-Chatillon, the remainder being entrusted to other works belonging to the company. The plant will eventually be erected in Haifa.

The new plant will contribute mainly to the production of artificial fertilisers.

ITALY

Synthetic rubber possibilities

The Ministry of Industry is conducting an enquiry with petroleum firms into the possibilities of producing synthetic rubber in Italy. During the war Italy produced a total of 13,000 tons of synthetic rubber in a factory at Ferrara, but this experiment was undertaken without regard to cost.

Trade and technical circles believe that, however satisfactory the results might be from the technical angle, the cost of the plant and equipment would be too high to permit any practical results to emerge.

BELGIUM

Casein factory to be built

A factory for the production of casein is to be built in Belgium, following a favourable report on such a project by the Institute for Economic Research. The plant is to be erected at Anvaing in the province of Hainaut. Nothing is known as yet regarding its capacity, but it is understood that the factory will, in the first place, be designed to supply casein to the single Belgian factory producing synthetic wool, which is also located at Anvaing. This factory has a daily consumption of 1,700 kg. of casein, while its daily output of synthetic wool amounts to 4,000 kg. Up to now, the casein required has had to be imported.

The new casein plant could obtain 500,000,000 litres of sour milk p.a., since Belgian domestic production of milk is in the region of 3,125,000,000 litres p.a.

EGYPT

Chemical factory planned

The establishment of a factory for chemical products, estimated to cost about £E500,000, is understood to be under consideration by the Egyptian Ministry of Commerce and Industry. Firms which have submitted offers for the building of the factory have stipulated that the Government should buy the products of the proposed factory for a period of five years at prices relevant to the cost of production.

BELGIAN CONGO

New cement works

A new cement works with an initial capacity of from 25,000 to 30,000 tons is to be built in the south of the Belgian Congo. It will start operations within a year. The new company will be known as the Ciments Metallurgiques de Jadotville and will have a capital of 40,000,000 Belgian francs subscribed in equal parts by Union Minière du Haut Katanga, les Ciments du Katanga, les Cimenteries et Briquetteries Réunies de Belgique and the Compagnie du Katanga. Metallurgical cement will be obtained by the grinding of a mixture of slag from Union Minière's electric furnaces at Jadotville, clinker, Portland cement and gypsum in proportions established as a result of tests undertaken by the Cimenteries et Briquetteries Réunies de Belgique.

The cement will be similar to normal-type Portland. With the extensions now in progress to the Katanga cement works, which will raise production to 150,000 tons, and the start of production at the new Albertville cement works (36,000 tons) in the spring of 1953, Katanga will have at their disposal a total cement capacity in the region of 220,000 tons.

AUSTRALIA

Oil refinery projects

Caltex Oils (Australia) Pty. Ltd. has announced that it is to apply to the Australian authorities for permission to proceed promptly with the building of a £A25,000,000 refinery. The announcement said the plant would have a capacity of 750,000 gal. daily and would be designed to refine a wide variety of crude oils. The announcement added that the company was studying possible locations for the refinery.

The Vacuum Oil Co. is also to build a refinery in Melbourne, at a total cost of £A7,500,000. Capacity of the new plant will be more than 500,000 gal. daily and all petroleum products will be produced —from high-octane petrol to fuel oil. Crude supplies will be obtained from Sumatra, New Guinea or the Persian Gulf, depending on availability. It may also be necessary to bring in dollar crude for lubricants, but this will be avoided as far as possible, as one of the chief purposes of the enterprise is the saving of dollar expenditure, according to a spokesman of the

Standard Vacuum Co. As far as possible, crude oil for lubricant manufacture will be obtained from the East Indies, and the prospecting in Papua now being undertaken jointly by Anglo-Iranian and Standard Vacuum will, it is hoped, also eventually yield crude oil suitable for lubricant manufacture.

The plant will be similar to the Esso Co.'s new refinery now partially in operation at Fawley, England, though it will be on a smaller scale. Construction work will start as soon as possible, and the plant is expected to be in operation in eighteen months' to two years' time.

Of the total cost of the refinery, £A4,500,000 will be spent on essential equipment unobtainable in Australia. Some of this will probably have to be spent in the U.S., but the aim is to reduce the dollar cost of the plant to a minimum, and as large a proportion as possible will be used for purchases in Britain.

This is the third oil refinery construction project to be announced this year. The Shell Co. of Australia started construction of a £A5,000,000 crude oil distillation plant at Geelong in June.

New refrigerator works

Refrigerator Compressors Ltd. will shortly build a factory on a 3-acre site near Launceston, Tasmania, and the headquarters of the company will later be transferred there from Brisbane. The firm, which has subsidiary factories in Melbourne and Sydney, also plans to erect plants in South Australia, West Australia and New Zealand.

The Tasmanian factory, said Mr. S. S. Norman, the company's Queensland manager, would, within the next twelve months, extend its activities (assembly of complete refrigerators and manufacture of open-type electric units) by building another plant, at a cost of £100,000, where a sealed unit would be made under licence from English interests. Between 30 and 40 technicians and their families would be brought from England for the new plant.

COLOMBIA

Fertiliser project

The Industrial Development Institute of Colombia has announced plans for construction of a nitrogen-fertiliser plant. A plant with a capacity of 20 metric tons daily could be erected for $4,490,000, or a 10-ton plant for $2,478,000, according to estimates made about February 1951 by a U.S. company. However, several engineers have expressed doubt as to whether plants could be constructed for these amounts. The site proposed is on the Magdalena River near the Barranca Bermeja oil fields, where a large amount of natural gas suitable for the production of ammonium sulphate is available.

Plans for the 20-ton plant call for a daily output of 20 tons of ammonia, 25 tons of nitric acid, 25 tons of ammonium nitrate (35% N), 25 tons of calcium nitrate (16% N) and 20 tons of ammonium sulphate (21% N). The 10-ton plant would have a daily output of 10 tons of ammonia, 29 tons of sulphuric acid, and 38 tons of ammonium sulphate. These figures represent capacity production, and it is not considered likely that the larger plant could operate at that rate at first. It is probable that domestic demand would be large enough to require capacity production of the 10-ton plant.

INDIA

Sulphur from coal deposits

Experiments carried out by the Fuel Research Institute on washability of coal in the Rewa District of Uttar Pradesh have indicated the presence of an abundance of sulphur in the coal deposits of this area. Tests carried out have established the possibility of obtaining 40 tons of sulphur from this source per day as a by-product.

The Institute is at present carrying out pilot-plant washing tests on behalf of a cement firm interested in putting up a coal washer for washing this coal for their cement plant. With the execution of their plan, it would be possible to obtain rich supplies of sulphur as a waste product.

At present India's total annual requirement of sulphur exceeds 65,000 tons and almost the entire quantity is imported from the U.S.A. and Italy and other countries.

Fertiliser factory's progress

Considerable progress has been made in the construction of the Sindri (Bihar) fertiliser factory which is scheduled to go into production in September this year. Construction of the power house and gas plant has been completed and the ammonia plant is nearing completion.

A portion of the sulphate plant is ready to enable initial production of ammonia sulphate.

According to present calculations, the plant is expected to produce 250,000 tons in 1952 and reach the target figure of 350,000 tons the following year.

U.N.O. fund for penicillin plant

A draft agreement for the manufacture of penicillin in India has been adopted at a meeting of representatives of the Indian Government, the World Health Organisation and the United Nations International Children's Emergency Fund, held at New Delhi. Under the agreement, the International Children's Emergency Fund will supply to India $850,000-worth of equipment for a penicillin factory which will be owned and controlled by the Indian Government. It has been stipulated that the Indian Government should distribute free to children and expectant mothers in India penicillin worth $850,000. The W.H.O., under the agreement, will provide technical assistance and training of Indian personnel at a cost of $350,000. It will also award fellowships in operation of the plant.

The penicillin plant, which will be installed at Dehu Road, near Poona, in Bombay State, will have a capacity of about 400,000 mega units a month. This will be increased to 750,000 mega units within two years. Production is likely to start in December 1953, while full production may be reached a year later.

International machinery exhibition

An International Industrial Machinery Exhibition is being held in Delhi from February 9 to March 24, 1952, under the patronage of the Government of India, who have agreed to grant special licences to exhibitors for the import of machinery. Exhibitors in the foreign division are invited to demonstrate, display and sell goods manufactured in any country, suitable for small- and medium-scale production, including engineering and scientific instruments, technical books, raw or semi-finished materials, pilot plants and machinery for the pharmaceutical, chemical and mining industries. The exhibition is being organised by the Association for the Development of the Swadeshi Industries.

MEXICO

Sugar production to be raised

Plans to increase sugar production to 1,000,000 metric tons annually in the course of the next few years have been announced by the Mexican Government. This is to keep pace with the continuous rise in domestic consumption, and it is not expected that any large quantities will be available for export.

Sugar production almost doubled between 1940 and 1950—from 292,000 to 590,000 tons. Consumption also rose from 363,000 metric tons in 1940 to 584,000 metric tons in 1950, and is expected to go up to 980,000 metric tons by 1955.

The programme, which will cost about 170,000,000 pesos, provides for the investment of 100,000,000 pesos in new and improved sugar mills, 30,000,000 pesos in irrigation works, 10,000,000 pesos for mechanical equipment and 30,000,000 pesos for the opening of about 75,000 acres of new land for cane cultivation, for the wider use of fertilisers and improved technical methods. The programme will be financed from the new retail and wholesale prices of sugar on the basis of 2 centavos for every kilogram sold. Collection of the fund will be in the hands of the National Union of Sugar Producers, which has been set up as the only organisation from which industrial users may buy.

New sulphur plant

A new sulphur plant is to be built at San Cristobel by the Mexican Gulf Sulphur Co. Mr. Norton, president, said his company had obtained a loan of $1,875,000 from the Export-Import Bank, which is believed sufficient to provide for construction costs plus additional working capital required.

PHILIPPINES

Sulphur dioxide plant

A sulphur dioxide gas plant is to be built at a cost of 2,000,000 pesos, to supply the projected Maria Cristina fertiliser plant, according to an announcement by the National Power Corporation in Manila. The Corporation is expected to sign shortly a contract which will provide supplies of pyrites ore from the Hixbar Mining Co.'s property. The Maria Cristina project is not expected to be completed before the end of 1952.

CANADA

Phenol acetone plant planned

Phenol is to be produced for the first time in Canada by a new plant to be set up at Montreal East by a recently formed petro-chemical company, B.A.-Shawinigan Ltd. It is also to produce acetone, and is expected to make Canada self-sufficient in both chemicals when it goes into operation late next year. The new company is jointly owned by the British American Oil Co. Ltd. and Shawinigan Chemicals Ltd.

The plant, estimated to cost $3,000,000 to $4,000,000, will make phenol and acetone by a new process under licence from the Hercules Powder Co. of Wilmington, Delaware, and the Distillers Corporation of Edinburgh.

Whereas, hitherto, sulphur or chlorine have been used in the production of phenol, the new process will dispense with both, since the primary raw material to be used will be cumene, plus oxygen from the atmosphere. Cumene, which is manufactured from propylene (a by-product of gasoline production) will be supplied from British American's refinery at Montreal East and oxygen from the atmosphere. The resultant cumene hydro-peroxide (itself one of the essential catalysts used in the newly developed cold rubber produced by the Polymer Corporation) is concentrated and then split into phenol and acetone.

Thus the new process will also release for other uses several hundreds of tons of carbide monthly now consumed in acetone production by Shawinigan Chemicals' plant at Shawinigan Falls, Quebec.

Shawinigan has hitherto been the only Canadian producer of acetone, and its output has been supplemented by small imports from Britain and the United States. However, the Shell Oil Co. has recently announced another petro-chemical project at Montreal East, which will make isopropyl alcohol and acetone.

B.A.-Shawinigan's Montreal East plant is expected to produce a total of 21,000,000 lb. p.a. of phenol, acetone and by-products.

U.K. firms interested in supplying equipment to the Shawinigan plant should write direct to Mr. R. B. Becknall, project engineer, Canadian Kellogg Co., 225 Broadway, New York City, who have been appointed chief contractors. Those wishing to tender for any of the equipment for the $3,000,000 Shell petroleum chemicals project should write to Mr. J. Courtwright, general purchasing agent, Shell Oil Co. of Canada, 25 Adelaide Street East, Toronto.

U.S.A.

New nickel alloy

An alloy has been developed by the International Nickel Co. for use under corrosive high-temperature conditions. *Incoloy*, as the new material is called, consists of about 35% nickel, 20% chromium and 45% iron. It is produced in most standard rolling mill forms and has been designed to take the place of some of the older alloys containing over 70% nickel.

Aluminium smelter planned

The Aluminium Co. of America has announced plans to build an $80,000,000 to $100,000,000 smelting plant in Milam County, about 60 miles south of Waco, Texas. It was stated that, if approved within a short time, the smelter would begin production by the early autumn of 1952 and would employ about 1,000 persons when in full operation.

Du Pont's new rubber laboratories

At a ceremony dedicating du Pont's $250,000 addition to its rubber research laboratories at Deepwater, New Jersey, officials of the company said that the laboratories will develop new products based on natural and synthetic rubber latex. Emphasis would be on new and improved latex products derived from *Neoprene*, the company's special oil- and sunlight-resistant synthetic rubber.

New soda ash plant

The *Solvay* process division, Allied Chemical & Dye Corporation, plans to expand its Baton Rouge soda ash plant. The cost of the necessary buildings, equipment and facilities will exceed $15,000,000, including certain new equipment at the company's limestone quarry which supplies the Baton Rouge plant.

New pilot-plant facilities have been completed at Hopenwell, Virginia, for the *Solvay* process division at a cost of $350,000. These facilities will co-ordinate previously scattered pilot-plant activities and contribute to the development of new *Solvay* products such as fertilisers, nitrogen products and synthetic organic chemicals.

New plastics factory

The B. F. Goodrich Chemical Co. is to build a $5,000,000 plant on a 175-acre tract in Calvert City, Kentucky. It was stated by the company that, when final approval was granted by the Defence Production Authority, construction would start on three buildings to house manufacturing operations, service and maintenance facilities, power plant and offices. First operations in the new structure were expected by late 1952 or early 1953.

The first product would be vinyl chloride monomer, a substance used in making resins widely used in plastic items. The monomer would be shipped in bulk to the company's Avon Lake, Ohio, plant, and would supplement supplies made at Louisville, Kentucky.

Sulphur from petroleum

The Deputy Petroleum Administrator, Mr. Brown, has announced that the U.S. petroleum industry, now producing 5,500 tons more sulphur than it is using in its own operations, has concrete plans that will shortly increase the supply of sulphur by 190,000 tons a year. Mr. Brown said that a comprehensive survey of refiners and industry by the Petroleum Administration for Defence established that through acid-recovery and sulphur-extraction operations the industry is directly reclaiming the equivalent of 170,000 tons of sulphur.

Hydrogen sulphide recovered from petroleum operations is being supplied to the chemical industry, which takes the equivalent of about 340,500 long tons of sulphur from it and about 133,000 additional tons of sulphur obtained from spent acids and acid sludges after they have been used in a series of petroleum operations.

New petroleum units

Cities Service has authorised the M. W. Kellogg Co. to design and engineer two large-capacity fluid hydroforming units. One, located at Lake Charles, Louisiana, will process more than 800,000 gal. daily, while the other, at East Chicago, Indiana, will handle about half this volume.

Hydroforming, that is the catalytic reforming of low-octane gasolines (naphthas), has been a process utilised in the U.S. since 1939, the most notable example being the plant at the Baytown Ordnance Works, which provided a large proportion of the toluene needs of the U.S. during the war. The new fluid hydroforming process, which is the result of extensive development work by the Standard Oil Development Co., the Standard Oil (Indiana) and Kellogg, radically improves the economics of the basic process by utilising the fluid catalyst principle. In these new units the catalyst, instead of being held in reactors, is finely powdered and moved continuously through the system supported on oil vapours and air. This eliminates the need for shutting down reactor vessels successively to regenerate the catalyst, which was the method employed previously. Considerable improvement is also obtained in the actual catalytic reaction, because the finely powdered catalyst provides better catalyst-oil contact than the pelletised variety required for the old-style reactors.

This fluid catalyst method is the continuous processing principle which is the basis of fluid catalytic cracking—the process conceived during the late thirties, which is now the backbone of modern refining.

According to Kellogg, the new fluid hydroforming process can reform 55-octane

naphtha to motor spirit with a clear octane rating of 95 CFR-R (without any tetraethyl lead). If an aviation spirit is desired, the process can produce fuels with rich-mixture aviation octane ratings of over 175 with the addition of 4.6 c.c. of tetraethyl lead.

Substitute for nickel

A white brass alloy consisting of four parts of zinc to one of copper has been developed by the du Pont Co. to replace nickel as a base for chromium finish in the plating industries. The company explained that it was customary to plate chromium over deposits of copper or a combination of copper and nickel, but recently the industry had been severely restricted in its use of nickel by the Government. The white brass is electrodeposited from a cyanide bath, using special brightening agents.

JAPAN

Chemical output down

Japanese output of chemicals declined generally in June, with only four out of twelve major items registering gains, according to the Ministry of International Trade and Industry. June output of calcium carbide totalled 57,500 tons against 67,249 tons in May, soda ash 21,390 (21,513), caustic soda 30,167 (30,499), sulphuric acid 328,390 (324,376), hydrochloric acid 16,313 (17,233), nitrate of lime 31,013 (42,583), superphosphate of lime 109,168 (117,000), synthetic dyestuffs 13,500 (13,900), soaps 13,500 (13,821), explosives 1,743 (1,698) and paint materials 8,300 (8,168).

ISRAEL

U.S. firm to build brewery

The construction of a modern brewery at Tel Aviv has been announced by the president of the Metropolis Breweries of New York and New Jersey.

Work on the new plant, which is being jointly financed by American and local interests, is already under way and is to be completed within a year.

Improved Plastics Foreseen

PROMISE of a new fast method for control of cure of plastics in commercial moulding operations and the discovery that molecular reorientation will increase tensile strength of polystyrene threefold are among results reported to the Manufacturing Chemists' Association, sponsors of a fundamental research programme on plastics being carried out at Massachusetts Institute of Technology.

Earlier results from the research have included development of new machines and techniques for testing plastics, methods of casting thin films for determination of mechanical properties, and demonstration of the utility of the turbidimeter for measuring molecular weight distribution of thermoplastic polymers. Principal objective of the programme is to fill gaps in existing data and provide the material necessary for development of theories on the fundamental behaviour of plastics under mechanical stress.

Control of thermosetting resins

In work currently in progress using ultrasonics, it has been shown that transmission and absorption of sound waves through thermosetting resins varies with their degree of cure. The rate and extent of cure can be followed by measuring the changes in velocity and intensity of sound waves passing through the plastic while it is in process of curing. These changes may be plotted graphically and correlated with other physical properties such as hardness, flexural strength, etc.

For the first time, it now seems possible to study in detail the changes taking place on curing of thermosetting resins as a function of temperature, type of catalyst, catalyst concentration and type of resin. Of equal importance, the investigations indicate the possibility of developing a reliable and rapid test method for commercial use in control of the degree of cure of thermosetting resins in the moulding shops.

Polystyrene research

Polystyrene is relatively brittle. When strained too far, as by bending or pulling, it cracks and finally breaks with a fracture which resembles that of glass. By 'combing' the polystyrene, however, so the molecules lie more parallel, the M.I.T. researchers found they were able to alter the characteristics of the material considerably. The combing, or orienting, was accomplished by stretching the polystyrene while it was hot enough to be plastic. After cooling, the stretched pieces showed ultimate strengths in the direction of stretch orientation approximately three times those of the unstretched pieces.

In highly stretched samples, the tendency to develop little cracks before rupture, known as crazing, disappeared. Under load sufficient to produce ultimate fracture, the oriented polystyrene exhibited much increased stretch (ductility) and behaved like steel or copper. Before rupture, the specimen 'necked down' at the place where fracture finally occurred, and the fracture was no longer shell-like but fibrous, like the ends of a thread which have been pulled apart. Various ideas were tried for the measurement of the degree of orientation. Low-angle *x*-ray diffraction pattern and bi-refringence of visible light showed that only a low order of orientation results from the stretching. No development of crystalline areas, as in metals, was found in polystyrene so prepared.

This knowledge is already being applied in the production of sheets of flexible polystyrene and indicates the possibilities of a polystyrene fibre for certain special-use fabrics.

The Leonard Hill Technical Group

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Fluorine Chemistry; Productivity in Pharmaceuticals; A New Source of Cortisone; Progress Reports on Analytical Chemistry and Antibiotics—MANUFACTURING CHEMIST.

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British Engineering and Welding Equipment; Oil Geology of Ethiopia; Third World Petroleum Congress—PETROLEUM.

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The Mechanical Properties of Fibres; Soft and Stiff Finishes in Textiles—TEXTILE INDUSTRIES AND FIBRES.

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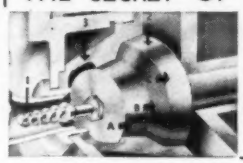

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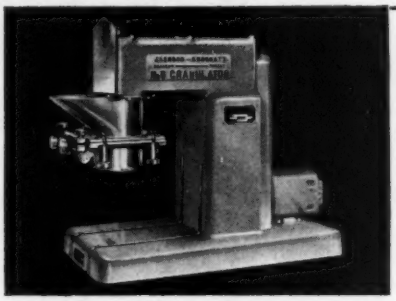

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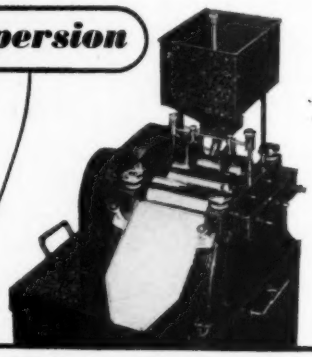

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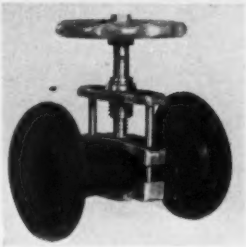

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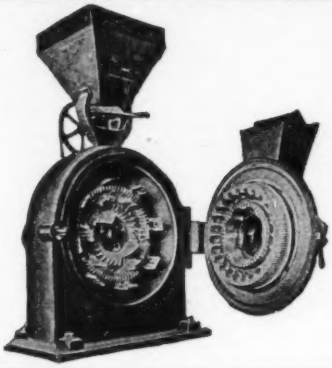

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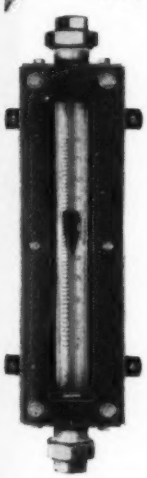

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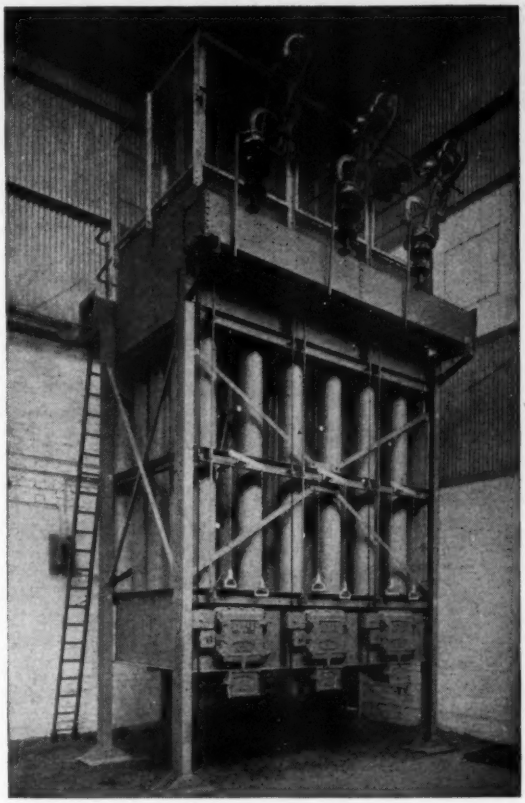

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